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VOLUME XXXV NUMBER 1

BOTANICAL GAZETTE

JANUARY, 1903

UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XXIV.[1]

JOHN DONNELL SMITH.

(WITH PLATE 1)

Clusia Salvinii Donn. Sm. (§ ANANDROGYNE Planch. et Triana).—Folia crassa oblongo-obovata apice rotunda in petiolum marginatum attenuata, nervis lateralibus late patentibus remotiusculis. Inflorescentia subspicata [illegible]ssata quinqueflora, pedicellis brevissimis basi bracteatis, floribus ipsis ebracteatis. Sepala 4 decussata. Petala 5 obovata sepalis parum majora. Antherae filamentis 3-plo longiores. Staminodia 5 libera e basi semiorbiculari dentiformia. Capsula globosa 5-locularis, seminibus in loculo quovis numerosis leviter ascendentibus.

Ramuli subteretes di–trichotomi. Folia 11-17 cm longa 5.5-9 cm lata margine revoluta, costa subtus tantum prominente infra apicem folii desinente, nervis angulo 60° a costa abeuntibus 3-4 mm inter se distantibus, nervo collectivo submarginali, venulis supra tantum manifestis, petiolis 1-1.5 cm longis. Pedunculus cum axe quadrangularis, pedicellis vix 2 mm longis, bracteis ovatis 5 mm longis. Sepala late suborbicularia 7-9 mm longa. Stamina 45-50 circiter 7 mm longa pistilli rudimentum includentia, receptaculo convexo 4 mm diam. metiente. Capsula 15-18 mm crassa basi sepalis paullo auctis et petalorum vestigiis cincta staminodiis 1.5 mm altis instructa, stylis 3-4 mm longis subconnatis, stigmatibus obovatis 2-3 mm longis in conum conniventibus, seminibus imbricatis circiter 20 plerumque abortivis. Flores feminini deficiunt.

Volcán de Fuego, Depart. Zacatepéquez, Guat., alt. 2600 m, Oct. 1873, *Osbert Salvin.*—Volcán de Fuego, Guat., alt. 2300 m, Mart. 1892, *Donn. Sm.*, n. 2530 ex Pl. Guat. &c., quas ed. Donn. Sm.

[1] Continued from BOT. GAZ. 33:262. 1902.

Melochia Bernoulliana Donn. Sm. (§ MOUGEOTIA K. Schum. in Mart. Fl. Bras. **12**[3]: 35).— Folia praeter nervos glabra magna lanceolato-ovata graciliter attenuata basi rotundata vel subcordata dupliciter serrata. Flores nunc in axillis fasciculati nunc in thyrsos axillares et terminales foliis plus minus breviores foliis reductis deciduis bracteatos dispositi. Calyx petalis triente brevior usque ad duas partes partitus, segmentis ovatis acuminatis. Tubus stamineus petalis bis superatus ultra medium fissus. Capsula breviter stipitata depresso-globosa calycem aequans profunde lobata.

Suffrutex 1-1.5 m altus, ramulis petiolis foliorum nervis inflorescentiae axibus calycibus capsulis minutissime stellulato-pubescentibus. Folia 8-13 cm longa 3-5 cm lata, nervis lateralibus praeter 1-2 utrinque basales inferiores breves parallelis utrinque 7-9, petiolis 1.5-3 cm longis ad apicem versus incrassulatis, stipulis cito deciduis. Pedicelli 2-7 mm longi. Calyx campanulatus 4 mm altus. Petala attenuato-oblanceolata 6 mm longa. Stamina 4 mm longa, filamentis liberis 1.75 mm longis, antheris 1 mm longis. Ovarium pilosum ovale 1 mm longum stylos liberos aequans vel eis dimidio brevius. Capsula pilis longis conspersa pentagona 4 mm longa, coccis loculicide indehiscentibus toto tergo dehiscentibus, seminibus glabris oblique lateque ovalibus 2.5 mm longis compressis.

Retalhuleu, Guat., 1877, *Bernoulli* et *Cario*, nn. 3112 et 3113.— Ad oras Río De Los Esclavos, Depart. Santa Rosa, Guat., alt. 800 m, Nov. 1892, *Heyde* et *Lux*, n. 4319 ex Pl. Guat. &c., quas ed. Donn. Sm.

Microsechium (?) compositum Donn. Sm.— Folia punctata supra scabriuscula subtus glabrescentia cordato-suborbicularia latiora quam longiora leviter obtuseque 5-7-lobata, margine denticulato. Inflorescentiae folia longe superantes, pedunculis simplicibus vel repetitus dichotomis, floribus 4-5-meris in racemulos dissitos confertis graciliter pedicellatis. Calycis tubus pateriformis 8-10-radiatus sub apice 8-10-foveolatus, dentibus minutis. Petala oblongo-ovata extus canescentia. Staminum filamenta gracilia usque ad medium coalita.

Altissime scandens. Folia membranacea subtus pallidiora cum sinu basilari subrectangulari 5–6 cm longo 3–4 cm lato adjecto 18–21 cm longa 22–26 cm lata, nervis in mucrones subulatos excurrentibus, petiolis glabrescentibus 10–16 cm longis. Cirrhi glabri elongati striati. Inflorescentiae cum pedunculis plerumque simplicibus 8–12 cm longis adjectis 35-50 cm longae, dichotomiis cirrhiferis, racemulis numerosissimis sessilibus vel pedunculatis multifloris, pedicellis 11–28 mm longis, floribus in sicc. intense viridibus plerumque pentameris

Calyx 5 mm latus, dentibus subulatis 2 mm longis. Petala patula intus puberula 5–6 mm longa 7-nervia. Staminum filamenta 5 mm longa supra medium radiata, antheris 4 vel saepius 5 suborbicularibus 1 mm longis bilocularibus, loculis flexuosis. Caules flores feminini fructus non suppetunt.— Hanc speciem solum ad folia et inflorescentias masculinas ex caule strictas constitutam Microsechio haud absque dubio adscripsi.

Malpais, Depart. Santa Rosa, Guat., alt. 1100 m, Sept. 1893, *Heyde* et *Lux*, n. 6146 ex Pl. Guat. &c., quas ed. Donn. Sm.

Psychotria anomothyrsa K. Schum. et Donn. Sm. (§ NOTOPLEURA Benth. in Oerst. Centralam. Rub. 37).— Folia maxima membranacea nitida oblanceolato- vel obovato-oblonga acuminata in petiolum longum complanatum attenuata. Pedunculi ex axillis alternis orti petiolis longiores, thyrsi ramis 2–3-nis, nunc semel vel bis dichotomis, nunc inferne trichotomis superne dichotomis, bracteolis oppositis alternatim floriferis, floribus minutis sessilibus secus axes binatim raro singulatim dissitis. Drupa pallida lineolis candidis farcta.

Suffrutex superne subherbacea simplex glabrescens hinc inde lineolatus. Folia subtus pallidiora 25–35 cm longa 9–17 cm lata, nervis lateralibus inter se 1–2 cm distantibus utrinque 9–14, petiolis marginatis 3–8 cm longis, stipulis deciduis. Pedunculi 6–12 cm longi sicut inflorescentiae axes complanati et marginati. Thyrsi cinereo-puberuli pyramidales vel oblongi 4–12 cm longi, axibus divaricatis nonnunquam recurvatis, bracteolis amplexicaulibus ovatis 1–2 mm longis. Calyx obpyramidatus 1.25 mm altus, dentibus obtusiusculis. Corolla glabra lineolata 4–5 mm longa usque ad tertiam vel quartam partem lobata, lobis ovatis. Stamina paullo infra fauces barbatas vel imberbes inserta, filamentis brevissimis. Drupa obovato-ovalis 5 mm longa 3.5 mm lata, endocarpio tenuissimo, pyrenis dorso profunde 4-sulcatis facie ventrali planis laevibus.— *P. uliginosae* Sw. proxima inflorescentiis anomalis insigniter distinguitur.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350 m, Dec. 1900, *von Tuerckheim*, n. 7909 ex Pl. Guat. &c., quas ed. Donn. Sm.— Prope Tarapoto, Peruvia Orientalis, 1855-6, *Spruce* sine numero.— El Recreo, Prov. Manabi, Ecuador, *Eggers*, n. 15.119. (Exemplaria Eggersiana thyrsos magis elongatos optime evolutos praebent.)

Rudgea ceratopetala Donn. Sm.— Folia elliptica vel oblongo-elliptica utrinque praesertim sursum longe contracto-acuminata, petiolis brevissimis, stipulis breviter oblongis apice aculeoligeris. Cyma longe pedunculata foliis paullo vel dimidio brevior laxiflora, floribus pubescentibus, lateralibus graciliter pedicellatis.

Corolla calyce 4-plo longior usque ad medium paene fissa, tubo cylindrico ad medium staminigero et ibidem tantum piloso, segmentis patentibus linearibus apice inflexo-cornutis.

Praeter flores glabra. Rami dichotomi. Folia chartacea 11–16 cm longa 4–6.5 cm lata, nervis lateralibus subtus conspicuis utrinque 8–10, petiolis 2–3.5 mm longis. Stipulae 3 mm longae aculeis cartilagineis pluribus incisae. Pedunculi 4–5 cm longi, cymis 3–5 cm altis 6–7 cm latis, ramis oppositis 2-jugis divaricatis bis dichotomis, floribus 5-meris in dichotomiis sessilibus, cymulis trifloris, pedicellis lateralibus subdivaricatis 7–9 mm longis, bracteis minutis triangularibus integris. Calycis 3 m alti limbus in sicc. pallescens cupulatus denticulatus tubum breviter cylindricum aequans. Corolla in sicc. fusca, segmentis 5 mm longis 3-nerviis cornu 1 mm longo appendiculatis. Antherae inclusae 3 mm longae filamentis 3-plo longiores. Stylus pubescens cum stigmatibus 2 mm longis adjectis corolla paullo brevior. Baccae ignotae. — Ad *R. micrantham* Muell. Arg. inflorescentia et calyce accedens foliis pedunculis corollis aliisque notis tamen recedit.

Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350m, 1901, *von Tuerckheim*, n. 7904 ex Pl. Guat. &c., quas ed. Donn. Sm.

Eupatorium hypomalacum Robinson.— Frutescens vel suffrutescens; ramis cortice griseo tectis subancipitibus, internodiis in parte superiore plus minusve sexangularibus pilis perbrevibus incurvatis vestitis; foliis oppositis lanceolatis integris vel obscure remoteque denticulatis acuminatis basi acutis penninervatis tenuibus supra laete viridibus in venulis sparse pubescentibus subtus pallidioribus molliter tomentosis et glanduliferis 12–14 cm longis 3.5–4.5 cm latis; petiolis subteretibus fulvo-tomentulosis 1.5 cm longis; thyrso pyramidato 1 dm longo; bracteolis oppositis perbrevibus griseis basi crassiusculis; capitulis parvis 8–10-floris, graciliter pedicellatis; squamis involucri paucis (10–12) valde inaequalibus pallide viridibus striatis sparse pubescentibus acutis, exterioribus lanceolatis, interioribus oblongis 4–5 mm longis; corollis albis glabris 2.4 mm longis, faucibus teretibus tubum proprium perbrevem superantibus, dentibus 5 brevissimis deltoideis; achenio 2.2 mm longo acute angulato in angulis sursum hispidulo; pappi setis subaequalibus circa 25 albis simplicibus.

This species shows a general affinity to *E. pinabetense* Robinson, *E. Tuerckheimii* Klatt, and *E. pansamalense* Robinson, although it is not very close to any one of these species.

Los Verdes, Depart. Amatitlán, Guat., alt. 1100^{m}, Aug. 1893, *Heyde* et *Lux*, n. 6157 ex Pl. Guat. &c., quas ed. Donn. Sm.

Sideroxylon uniloculare Donn. Sm.—Folia glabra maxima oblongo- vel obovato-elliptica cuspidato-acuminata basi cuneata, nervis lateralibus parallelis remotis utrinque conspicuis, petiolis brevibus. Calycis segmenta basi coalita jam in alabastro aperta. Corollae calyce dimidio longioris lobi orbiculares. Stamina cum staminodiis eis paullo longioribus lanceolatis sub apice tubi affixa, antheris subsessilibus lateraliter dehiscentibus. Ovarium depresso-obpyramidatum 1-loculare, ovulo unico nunc pendulo nunc lateraliter affixo.

Folia coriacea 13–21^{cm} longa 6–9^{cm} lata, cuspide obtusiuscula, nervis lateralibus inter se 1–1.5^{cm} distantibus utrinque 12–14 subtus validis, venis minutissime reticulatis subtus prominulis, petiolis canaliculatis 8-15 ^{mm} longis. Pedicelli ferrugineo-pubescentes dense fasciculati 7^{mm} longi, floribus 5-meris. Calyx ferrugineo-pubescens 2^{mm} altus usque ad duas partes fissus, segmentis ovatis consimilibus. Corolla glabra, lobis tubum bis superantibus margine erosis. Antherae ovatae 0.5^{mm} longae pilis albidis conspersae. Staminodia 1^{mm} longa subintegra. Ovarium pubescens 0.75^{mm} altum 1.5^{mm} latum, stylo subulato 0.5^{mm} longo, stigmate parvo integro. Bacca mihi non visa.

Secus Río De Las Vueltas, Tucurrique, Costa Rica, alt. 635^{m}, Maj. 1899, *Tonduz*, n. 13358 herb. nat. Cost.

Styrax polyneurus Perk.—Arbor, rami subteretes, juniores fusco-tomentosi, adulti demum glabrescentes, folia 1-1.5^{cm} longe petiolata, lanceolata vel obovato-lanceolata vel obovato-oblonga, 12–9^{cm} longa, 4–2.25^{cm} lata, basi in petiolum a latere compressum sensim cuneato-angustata, apice acuta vel breviter late acuminata, apice ipso acutiusculo, papyracea vel subchartacea, integra, supra juniora hinc inde pilos stellatos minutos gerentia, adulta glabra, subtus pilis albidis lepidotis stellatis tomentosa, nervis 6–9-jugis venisque supra vix, subtus valde prominentibus, venis validioribus inter sese parallelis rectangulariter costae insedentibus, omnibus dense reticulatis; flores ignoti; fructus ovoideus, 7^{mm} longus, 3-4^{mm} crassus, breviter mucronatus, lepidibus argenteis dense tectis.—Ab incolis *Resina* dicitur.

This species is closely related to *S. myristicifolius* Perk. in Bot. Jahrb. 31: 481, but differs from it in the form and nervature of the leaf, and in the color and shape of the hairs on the under surface. It is very noticeable that

the fruit of *S. polyneurus* is much smaller than that of *S. myristicifolius*, and that it is densely covered with silvery scales.

In silvis ad Copey, Cost., alt. 1800m, Febr. 1898, *Tonduz* n. 11744 herb. nat. Cost.

Dianthera sulfurea Donn. Sm. (§ JACOBINIOIDEAE, Ser. E. Benth. et Hook.)—Folia brevissime petiolata ovato-lanceolata in apicem obtusiusculum producta basi rotunda vel subcordata praeter nervos venasque glabrescentia. Pedunculi axillares foliis 3–4-plo breviores, spica subcapituliformi triflora, floribus pedunculum paullo superantibus. Calyx bracteolis aequilongus, segmentis 4 lanceolato-linearibus. Corolla flava densissime longeque pilosa usque ad medium fere bilabiata, labio postico integro. Antherae sagittatae, connectivo triangulari.

Suffrutex 1–2-metralis, ramis brachiatis declinatis teretibus unifariam pubescentibus. Folia 6–9 cm longa 2–3.5 cm lata basi saepe inaequalia supra cystolithiis dense atro-lineolata, petiolis pubescentibus 2–3 mm longis. Pedunculi pilis conspersi 15–25 mm longi, bracteis 5 mm et bracteolis 8 mm longis attenuato-linearibus glandulari-pilosis. Calycis segmenta basi breviter coalita pilosula. Corolla 26–28 mm longa, tubo recto superne paullo ampliato, labio postico erecto, antici paullo brevioris lobulis 2–3 mm longis. Stamina labium posticum aequantia, antheris 3 mm longis basi 2 mm latis, loculis oblongis divergentibus, altero breviore paululum inferius posito. Discus cupularis. Ovarium oblongum 2.5 mm altum 4-ovulatum, stylo 28 mm longo. Capsula ignota.—*D. latifoliae* Benth. et Hook. proxima differt insigniter corollae colore.

Cerro Redondo, Depart. Santa Rosa, Guat., alt. 1200m, Sept. 1893, *Heyde et Lux*, n. 6215 ex Pl. Guat. &c., quas ed. Donn. Sm.

Ocotea tenera Mez et Donn. Sm.—Foliis submembranaceis, glaberrimis, anguste vel bene ellipticis, basi acutis apice elegantissime acuminatis, penninervibus, utrinque sed praesertim subtus laxe prominulo-reticulatis; inflorescentiis tenerrimis, laxis squarrosisque, ♂ tripinnatim, ♀ bipinnatim paniculatis, quam folia brevioribus; floribus subdioicis, glaberrimis; tubo perianthii brevissimo; filamentis glabris vel pilis perpaucis, brevissimis praeditis, ♂ quam antherae subrectangulares, anguste rotundatae paullo longioribus, ♀ paullo brevioribus; staminodiis nullis vel minutissimis, stipitiformibus; ovario glabro, stylo crassiusculo, breviore.

Ramuli gracillimi, glaberrimi, cortice esipido, mucoso. Folia petiolis vix ultra 10 mm longis, tenuibus stipitata, sparsa vel subdisticha, utrinque sed praesertim subtus nitidula, plus minus 120 mm longa, 40 mm lata, sicca nunc manifestius nunc obscurius nigrescentia et margine (saepius non nisi minute) crispulata. Inflorescentiae ♂ submultiflorae, ♀ pauciflorae, pedicellis gracillimis usque ad 5 mm longis, bracteis deciduis. Flores 2–2.5 mm longi, limbi segmentis aequalibus, e late ovato ♂ longius ♀ breviter acutis, constanter punctulis numerosissimis mucosis in sicco prominulis aqua mollitis sub lente optime pellucidis insignibus. Glandulae florales filamentis ser. III basi affixae, e minoribus, globosae. Ovarium floribus ♂ quoque haud male evolutum. Bacca ellipsoidea, plus minus 22 mm longa, 11 mm diam. metiens, cupulae parvae, simplicimarginatae, planiusculae, sensim in pedicellum clavatim incrassatum transeunti insidens, inflorescentiae cuique fructiferae singula evoluta.

Turrialba, Prov. Cartago, Cost., alt. 570 m, Jun. 1895, *Tonduz*, n. 8330 herb. nat. Cost.— In silvis prope Shirores, Talamanca, Cost., alt. 100m, Febr. 1895, *Pittier* et *Tonduz*, n. 9184 herb. nat. Cost.— La Colombiana, Llanuras de Santa Clara, Cost., alt. 200m, Jun. 1899, *Pittier*, n. 7607 ex Pl. Guat. &c., quas ed. Donn. Sm. (n. 13396 herb. nat. Cost.)

Croton pyramidalis Donn. Sm. (§ EUCROTON Muell. Arg.)—Folia oblongo-ovata acuminata cordata abbreviato-3–5-nervia basi biglandulosa discoloria supra sparsim subtus densissime ciliatolepidota. Racemi in paniculas unisexuales axillares terminalesque amplas dispositi, masculini floribundi, feminini sparsius floriferi, floribus solitariis, femininis brevius pedicellatis. Floris ♂ petala oblonga, stamina 15. Floris ♀ petala nulla, styli 4-fidi.

Arbor. Indumentum lepidibus ciliato-radiatis quasi tomentulosum in ramulis petiolis foliorum nervis paniculis calycibus ferruginascens. Folia 10–17 cm longa 5–9 cm lata integra subtus canosa, petiolis 3.5–5 cm longis, stipulis subulatis 3–4 mm longis deciduis. Paniculae foliis reductis inferne suffultae subpyramidales 11–18 cm longae, bracteolis subulatis 3–4 mm longis deciduis. Floris ♂ calyx campanulatus 4 mm altus pedicellum subaequans, glandulis obovatis crassis, segmentis breviter coalitis ovatis intus glabris, petala calyci aequilonga extus cano-villosa, stamina praeter basin glabra 7 mm longa, antheris lineari-ellipticis 2 mm longis, receptaculum cano-villosum. Floris ♀ calyx mari similis pedicello bis longior, glandulis inconspicuis, ovarium lepidotum hemisphericum 2.5 mm latum, stylis lepidotis crassis 1.5 mm longis apice ramos 4 glabros simplices 2 mm longos ferentibus, capsula globosa 5.5-diametralis, seminibus nitidis atris rugulosis.—Ad *C. paniculatum* Muell. Arg. nonnullis notis accedit, paniculis unisexualibus (an dioicis ?) tamen recedit; hanc ob rem affinitas systematica perincerta est.

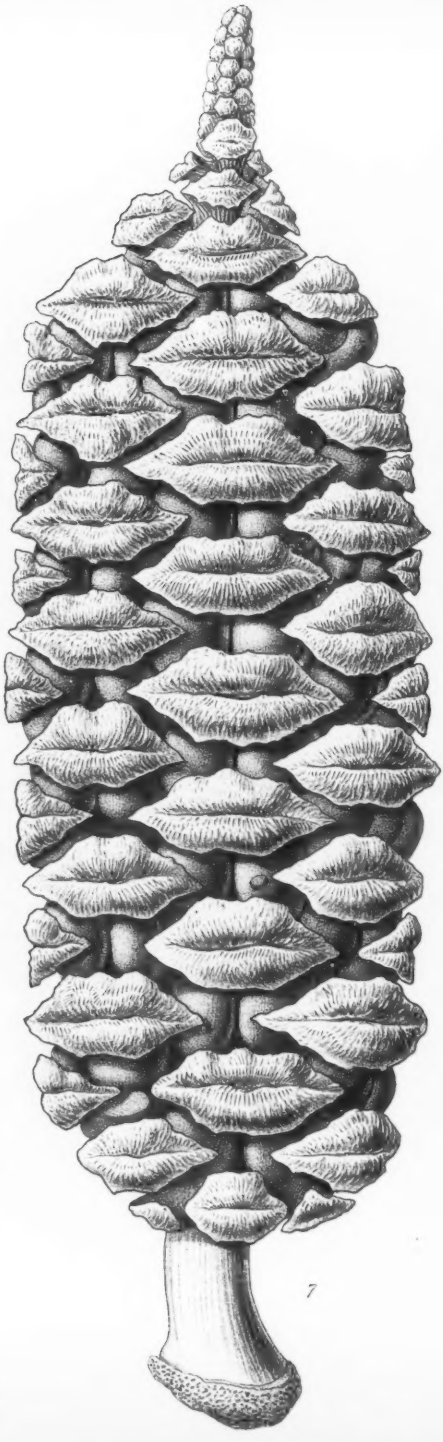
Ad oras Río Dolores in fundo Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Jul. 1901, *von Tuerckheim*, n. 7974 ex Pl. Guat. &c., quas ed. Donn Sm.— Eandem plantam, ut videtur, a cl. E. P. Johnson in Yucatan vel Tabasco sub n. 118 lectam in Herb. Kew. inveni.

Zamia Tuerckheimii Donn. Sm.— Folia glabra 14-jugo-pinnata, rhachi petiolum sparsim minuteque aculeatum bis superante ultra foliola graciliter producta, foliolis suboppositis oblanceolatis abrupte breviterque acuminatis in basin perangustam attenuatis integerrimis, nervis in medio folioli 40 et ultra in basi circiter 8. Strobilus ♂ lineari-cylindricus pedunculo bis longior, staminibus tota facie inferiore praeter plagam mediam angustam loculigeris. Strobilus ♀ brevissime pedunculatus longe cuspidato-acuminatus, carpidiorum seriebus et verticalibus et horizontalibus circiter 9.

Truncus saxifragus primum pendens demum ascendens 1.5–3^{m} longus 2^{dm} crassus nonnunquam furcatus (De Tuerckheim in litt.). Folii rhachis trigona circiter 9^{dm} longa, internodiis 5–7^{cm} longis, mucrone terminali 1.5^{cm} longo, foliolis firmo-chartaceis supra nitidulis subtus pallidioribus 19–24^{cm} longis medio 4–5^{cm} basi 3^{mm} latis. Strobilus ♂ 14^{cm} longus 2.5^{cm} crassus apiculatus, peltis cano-farinosis truncato-pyramidatis subaequaliter hexagonis, staminum seriebus verticalibus circiter 24, horizontalibus circiter 36, loculis 18–26 globosis discretis vel binatim cohaerentibus. Strobilus ♀ pedunculo 2^{cm} longo sustentus 18^{cm} longus 6^{cm} crassus, cuspide peltis sterilibus adspersa tenuiter conica 3^{cm} longa, peltis cinereo-tomentulosis planis hexagonis bis et ultra latioribus quam longioribus. Semina coccinea obovoidea 2^{cm} longa 13^{mm} lata.— Monente Thiselton-Dyer, Hort. Bot. Reg. Kew, claro rectore, *Z. acuminatae* Oerst. ex Dyer in Hemsl. Biol. Centr.-Am., necnon *Z. Houtteanae* This.-Dyer, MS. in Herb. Kew, affinis; haec tamen foliolis falcatis vix acuminatis, illa foliolis paucioribus sensim tenuiterque acuminatis, utraque nervis minus crebris, diversa; utriusque strobili ignoti.

In praecipitiis saxosis udis umbrosis prope Cubilquitz, Depart. Alta Verapaz, Guat., alt. 350^{m}, Jul. 1900, *von Tuerckheim*, n. 7786 ex. Pl. Guat. &c., quas ed. Donn. Sm.

EXPLANATION OF PLATE I.—FIG. 1, leaf, reduced to ⅛ natural size.—FIG. 2, leaflet, natural size.—FIG. 3, staminate strobile, natural size.—FIG. 4, vertical view of stamen, enlarged.—FIG. 5, upper side of stamen, enlarged.—FIG. 6, lower side of stamen, enlarged.—FIG. 7, strobile in fruit, natural size.—FIG. 8, lower side of carpidium, enlarged.—FIG. 9, upper side of carpidium, enlarged.—FIG. 10, seed, enlarged.—FIG. 11, vertical section of seed, enlarged.—FIG. 12, embryo, enlarged.



C. E. Faxon del.

ZAMIA TUERCKEIMI

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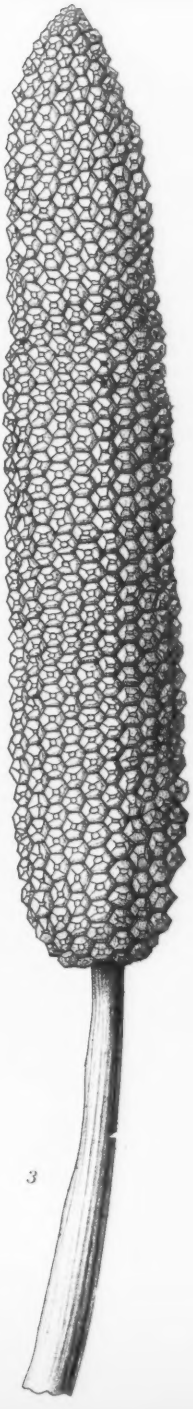

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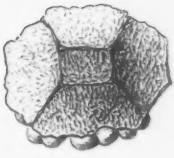

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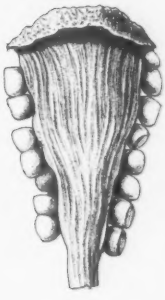

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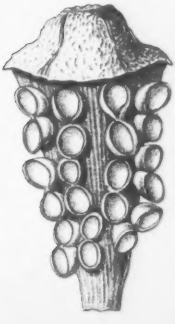

E. Meyer, Lith. Boston

TUERCKEIMII, Donn. Sm.

Guzmania Donnellsmithii Mez (§SCHLUMBERGERIA Morr.)—Foliis adultis dorso saltem lepidibus numerosissimis parvis pallidis conspersis; inflorescentia bipinnatim densiuscule panniculata e spicis breviter quidem sed tamen manifeste stipitatis, 3-floris composita; bracteis florigeris quam sepala basi breviter connata multo brevioribus; petalis tubulose erectis absque dubio alte connatis quam sepala vix ultra 5^{mm} longioribus.

Acaulis, florifera paullo ultra 0.3^{m} alta. Folia multa dense rosulata, basi in vaginam paullo ventricosam, ovalem, optime denseque lineis violaceis longitudinaliter striatam dilatata, non nisi imperfecte cognita verisimiliter in apicem acutum sensim angustata. Scapus foliis non nisi summis vaginaceis, stricte erectis, persensim acutissimis, internodia perlonge superantibus involutus et omnino celatus, erectus. Inflorescentia verisimiliter folia paullo superans, submultiflora, breviter thyrsoidea, mihi visa 110^{mm} longa, ex sicco pulchre rubens; axibus glabris; bracteis primariis amplis, ex ovato acuminatis, summis quam spicae axillares bene brevioribus, inferioribus eas longe superantibus; bracteis florigeris late ellipticis, rotundatis, haud carinatis, membranaceis, inferioribus ad 8^{mm} longis, 4^{mm} latis; spicis paullo laxiusculis bene quaquaverse florigeris, inferioribus pedunculis 5.6^{mm} longis crassiusculis nudis stipitatis. Flores subsessiles, 21^{mm} longi, tenues gracilesque, erecti; sepalis 16^{mm} longis, basi breviter aequaliterque connatis, explanatis fere lineari-ellipticis, apice rotundatis, haud carinatis. Petala usque ad 5^{mm} ab apice in tubum perfectum cylindricum connata, lobis ut videtur per anthesin erectis, ovatis, bene rotundatis. Stamina petalis breviora eorumque fauci inserta, filamentis apice brevissime tantum liberis, antheris 2.5^{mm} longis, sublinearibus, acutis. Ovarium ellipsoideum, stylo gracillimo, stigmatibus breviter clavatim contortis.—Species absque dubio ordinis e pulcherrimis hortulanisque quam maxime requirenda *G. Zahnii* Mez valde accedit, differt tamen, ne plura proferam, spicis paucifloris.

In silvis profundis Suerrensibus, Llanuras de Santa Clara, Cost., alt. 300^{m}, Febr. 1896, *Donn. Sm.*, n. 6824 ex Pl. Guat. &c., quas ed. *Donn. Sm.*

BALTIMORE, MD.

CULTURES OF UREDINEAE IN 1902.[1]

J. C ARTHUR.

THE present article forms the third of a series of reports by the author upon the cultures of plant rusts. The first one[2] covered the year 1899, the second[3] combined the years 1900 and 1901, and the third covers the year 1902. Like the preceding ones, the present report is devoted largely to the heteroecious grass and sedge rusts. The methods employed have already been described in connection with the previous reports.

The work was much more extended during the present season than had been possible in preceding years through the interest taken in it by the authorities of Purdue University, who generously defrayed the expense of additional assistance during the months of May and June, when the largest part of the work must be done. In this way it became possible to have the help for a time of Mr. Oliver P. Terry, an undergraduate of the university, and an unusually skilful manipulator. But the larger part of the testing with drop cultures and of the application of the spores to the plants throughout the whole of the busiest period was undertaken by Miss Julia Titus Emerson, of New York City, coming from the New York Botanical Garden, who showed great earnestness and rare judgment in carrying on the work.

During the present season 123 collections of material were employed, and 314 drop cultures were made from them to test the germinating condition of the spores. Out of these 23 collections refused to germinate, and were consequently useless. There were in all 327 plant cultures attempted, representing 43 species of rusts, and employing 102 species of hosts tempo-

[1] Read before the Botanical Society of America, Washington, Jan. 1, 1903.

[2] BOT. GAZ. **29**: 268–276. April 1900.

[3] Jour. Mycology **8**: 51–56. June 1902.

rarily grown in pots in the greenhouse. In no case was success attained where definite clues derived from field observations were lacking.

Fourteen species were tried this year by the guessing method, no clues being known, and the following is a record of the failures, together with one instance, that of the Panicularia rust, where a seeming clue also failed. Teleutospores were employed in every case.

1. MELAMPSORA from *Populus deltoides* Marsh. was sown on *Larix europaea*, *Abies balsamea*, *Euonymus obovatus*, *Stylophorum diphyllum*, *Helianthus strumosus*, and *H. grosse-serratus*, with no infection.

2. MELAMPSORA on *Salix discolor* Muhl. was sown on *Larix europaea*, *Abies balsamea*, *Picea canadensis*, *Euonymus obovatus*, *Ribes aureum*, *R. gracilis*, and *Helianthus grosse-serratus*, with no infection.

3. UROMYCES JUNCI Tul. from *Juncus tenuis* Willd. was sown on *Iris versicolor*, with no infection.

4. UROMYCES SPOROBOLI E. & E. from *Sporobolus longifolius* (Torr.) Wood was sown on *Ceanothus americanus* and *Verbena stricta*, with no infection.

5. UROMYCES HALSTEDII De T. from *Homalocenchrus virginicus* (Willd.) Britt. was sown on *Senecio obovatus* and *Bidens frondosa*, with no infection.

6. PUCCINIA ELEOCHARIDIS Arth. from *Eleocharis palustris* (L.) R. & S. was sown on *Iris versicolor*, with no infection.

7. PUCCINIA SCHEDONNARDI K. & S. from *Schedonnardus paniculatus* (Nutt.) Trel. was sown on *Lepidium apetalum*, *Ceanothus americanus*, *Oxalis cymosa*, *Apocynum cannabinum*, *Cassia Chamaecrista*, *Symphoricarpos racemosus*, *Xanthium canadense*, *Kuhnistera purpurea*, and *Lacinaria scariosa*, with no infection.

8. PUCCINIA MUHLENBERGIAE A. & H. from *Muhlenbergia racemosa* (Mx.) B. S. P. was sown on *Napaea dioica*, *Impatiens aurea*, *Oxalis cymosa*, *Anemone canadensis* and *A. virginiana*, *Hydrophyllum appendiculatum*, *Phlox divaricata*, *Physalodes Physalodes*, *Apocynum cannabinum*, and *Helianthus grosse-serratus*, with no infection.

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9. PUCCINIA CHLORIDIS Speg. from *Chloris verticillata* Nutt. was sown on *Quamasia hyacinthina*, with no infection.

10. PUCCINIA SPOROBOLI Arth. from *Sporobolus heterolepis* Gray was sown on *Isopyrum biternatum*, *Oxalis cymosa*, *Xanthoxylum americanum*, *Ribes Cynosbati*, *Cassia Chamaecrista*, *Symphoricarpos racemosus*, *Verbena urticifolia*, *Senecio obovatus*, *Solidago rigida*, *Helianthus Maximiliani*, *Boltonia asteroides*, and *Brauneria purpurea*, with no infection.

11. PUCCINIA PURPUREA Cke. from *Tripsacum dactyloides* L. was sown on *Zea Mays*, with no infection.

12. PUCCINIA STIPAE Arth. from *Stipa spartea* Trin. was sown on *Aesculus glabra*, *Cassia Chamaecrista*, *Psoralea Onobrychis*, *Symphoricarpos racemosus*, *Hydrophyllum appendiculatum*, *Xanthium canadense*, *Boltonia asteroides*, *Lacinaria scariosa*, and *Brauneria purpurea*, with no infection.

13. PUCCINIA PANICULARIAE Arth. from *Panicularia americana* (Torr.) MacM. was sown on *Boltonia asteroides*, with no infection, although three sowings were made at different dates and with all conditions apparently favorable. This seems to contradict the inference of the writer drawn from field observations (Bull. Torr. Bot. Club **28**: 664).

14. PUCCINIA EMACULATA Schw. from *Panicum capillare* L. was sown on *Impatiens aurea*, *Lactuca canadensis*, and *Eupatorium perfoliatum*, with no infection.

15. PUCCINIA POLYGONI-AMPHIBII Pers. from *Polygonum emersum* (Mx.) Britt. was sown on *Polygonum pennsylvanicum* and *P. virginianum*, with no infection.

Twelve species of rusts were successfully grown, that have been studied with success before, and reported upon by the writer and others. They are enumerated here by way of confirmation, and also in some cases because additional hosts are included. The list is as follows:

1. UROMYCES EUPHORBIAE C. and P.—June 19, aecidiospores from *Euphorbia humistrata* Engelm. were sown on the same host, and were followed by uredo on July 8, and also on *E. nutans* and *E. marginata*, with no infection. July 11, aecidiospores from

E. nutans Lag. were sown on the same host, and were followed by uredo on July 21, and also on *E. humistrata* and *E. marginata*, with no infection. July 22, uredospores from *E. dentata* Michx. were sown on the same host, and were followed by uredo on Aug. 14, and also on *E. humistrata*, *E. nutans*, and *E. marginata*, with no infection. These results, taken in connection with those previously obtained by the writer,[4] leave no opportunity for doubt that the Euphorbia rust is separable into a number of well established races, or possibly into true species.

2. UREDO RUBIGO-VERA DC.— May 31, uredospores from *Triticum vulgare* Vill. were sown on *Triticum vulgare*, and produced uredo on June 13, and at the same time on *Hordeum jubatum*, *Poa compressa*, *Dactylis glomerata*, and *Bromus ciliatus*, with no infection.

3. PUCCINIA PECKII (De T.) Kellerm.— The connection of a Puccinia on *Carex trichocarpa* Muhl. and *Aecidium Peckii* De T. on *Onagra biennis* (L.) Scop. (*Oenothera biennis* L.) has already been reported by Kellerman,[5] and it was due to the suggestion from Professor Kellerman, founded upon his field observations, that the writer succeeded in bringing the present season's work to a satisfactory issue.[6] Eleven collections of teleutospores were used: two from Ohio, sent by Professor Kellerman; two from Racine, Wisconsin, sent by Dr. J. J. Davis; two from Spirit Lake, Iowa, obtained by the writer; and the remainder from different localities near Lafayette, Indiana. Seven of these collections were definitely known to be on *Carex trichocarpa*, and four of them, those from Wisconsin and Iowa, were presumably on that host.

Spores from these collections were sown on *Urtica gracilis*, *Anemone canadensis*, *Geranium maculatum*, *Impatiens aurea*, *Sambucus canadensis*, *Ribes gracile*, *R. Cynosbati* and *R. floridum*, *Xanthium canadense*, *Aster Shortii* and *A. paniculatus*, *Solidago canadensis*, *Erigeron annuus*, and *Leptilon canadensis*, with no infection. Successful cultures on *Onagra biennis* were made as follows, the

[4] BOT. GAZ. 29:271. 1900, and Jour. Mycology 8:51. 1902.

[5] Jour. Mycology 8:20. 1902.

[6] For record of previous failures see Jour. Mycology 8:52. 1902.

period between the sowing of the dry spores and the appearance of the spermogonia varying from five to seven days, and between the appearance of the spermogonia and the appearance of the aecidia an equal length of time, the two intervals making ten to thirteen days.

CULTURES OF PUCCINIA FROM CAREX TRICHOCARPA ON ONAGRA BIENNIS.

Teleutospores sown	Spermogonia appeared	Æcidia appeared
April 26	May 1	May 7
May 2	May 8	May 13
May 2	May 8	May 15
May 2	May 9	May 15
May 5	May 10	May 16
May 7	May 12	May 19
May 7	May 13	May 19
May 7	May 14	May 19
May 7	May 14	May 19
May 9	May 15	May 21
May 27	June 2	June 7
May 28	June 2	June 7
May 29	June 4	June 9

A collection on *Carex stipata* Muhl. also was made near Lafayette, Indiana, spores from which were sown on *Ribes Cynosbati*, *R. floridum*, *R. Uva-crispa*, *Aster paniculatus*, *A. prenanthoides*, *Solidago canadensis*, and *S. serotina*, with no infection. It was not until aecidia were found in the field on seedlings of *Onagra biennis*, growing close to the Carex still bearing dead leaves covered with teleutospores, that the right plant was selected for cultures. Teleutospores were sown on *Onagra biennis* June 23; spermogonia appeared in great abundance July 1, and aecidia July 8.

4. PUCCINIA BOLLEYANA Sacc. and P. ATKINSONIANA Diet.—The connection of *Puccinia Bolleyana*, which occurs on *Carex trichocarpa* Muhl., with *Aecidium Sambuci* Schw. has already been reported by the writer.[7] This has been confirmed by further successful trials. Material gathered from the type locality of *P. Bolleyana*, when examined under the microscope, was found to show only a small proportion of the characteristic spores of

[7] Jour. Myc. **8**: 55.

this species, and a large proportion of much smaller spores, which were surmised to belong to *Puccinia Peckii*. Sowings were made, May 5, on *Sambucus canadensis* and *Onagra biennis*. May 10, abundant spermogonia appeared on Onagra, followed May 16 by aecidia. On Sambucus spermogonia appeared sparingly May 13, followed by aecidia May 21. The sedge, therefore, bore two species of rust in 1901, intermixed on the same leaves. In addition to this, on May 19, aecidiospores from *Sambucus canadensis* were sown on *Carex trichocarpa*, which gave rise to uredo on May 27. The connection of *Puccinia Bolleyana* with *Aecidium Sambuci* appears to be proven beyond question.

Two collections of *Puccinia Atkinsoniana* on *Carex lurida* Wahl. were sent from Columbus, Ohio, by Professor Kellerman, with the suggestion, which seemed to me at the time very improbable, that the aecidia doubtless occurred on *Sambucus canadensis*. Another collection was secured from the vicinity of Lafayette, Indiana. Two sowings were made on *Onagra biennis* without infection. One sowing from each of the three collections was made on *Sambucus canadensis* with abundant success in each case. The dates are respectively April 28, May 7 and 16; April 29, May 5 and 16; and May 7, 12, and 21. Professor Kellerman has written me that his cultures also gave similar results.

These discoveries led to a careful microscopic study of the two Carex rusts, and there appears to be no reason to question that *P. Atkinsoniana* and *P. Bolleyana* are identical. In the designation of the species it seems necessary on grounds of priority to abandon both these names, however, and it becomes **Puccinia Sambuci** (Schw.), nom. nov.

5. PUCCINIA CARICIS-ASTERIS Arth.—A collection of this species on *Carex foenea* Willd. was sown on *Solidago serotina*, with no infection. It was also sown, May 2, on *Aster paniculatus* Lam., and was followed by spermogonia May 8, and aecidia May 19, thus confirming the writer's previous work.[8]

6. PUCCINIA CARICIS-ERIGERONTIS Arth.—A collection of this rust on *Carex festucacea* Willd. was used for cultures on *Erigeron*

[8] Jour. Mycology **8**:54. 1902.

annuus (L.) Pers., *E. philadelphicus* L., and *Leptilon canadense* (L.) Britt., with the most unqualified success. The work of last year[9] is thus confirmed, and additional hosts ascertained.

7. PUCCINIA CARICIS (Schum.) Reb.—A collection of this rust on *Carex stricta* Lam., sent by Rev. J. M. Bates from Callaway, Nebraska, gave rise to aecidia when sown on *Urtica gracilis* Ait., the dates for sowing, appearance of spermogonia and aecidia being respectively May 24, June 2 and 7. The experimental proof of this connection has been reported[10] twice previously for American material. A collection sent by Mr. E. W. D. Holway from Decorah, Iowa, on *Carex riparia* Curt. was sown on *Ribes Cynosbati*, *R. gracile*, *R. aureum*, *R. floridum*, and *R. Uva-crispa*, *Geranium maculatum*, *Onagra biennis*, *Sambucus canadensis*, and *Xanthium canadense*, with no infection. It was sown on *Urtica gracilis* May 21, and gave spermogonia May 27, and aecidia June 2.

8. PUCCINIA VILFAE A. & H.—The alternate form of this rust has been shown[11] to be *Aecidium verbenicola* K. & S. These results have been verified this season by sowing teleutospores from *Sporobolus longifolius* (Torr.) Wood, collected at Callaway, Nebraska, by Rev. J. M. Bates, on *Verbena stricta* Vent. (culture dates May 28, June 3 and 10) and on *V. urticifolia* L. (culture dates the same). A collection from Lafayette, Indiana, on the same host, was also sown on *V. urticifolia* with success (culture dates May 2, 10, and 19). To conform to present knowledge the name of the rust should be written **Puccinia verbenicola** (K. & S.), nom. nov.

9. PUCCINIA WINDSORIAE Schw.—A collection of the teleutospores of this species of rust on *Tricuspis seslerioides* Torr. (*Triodia cuprea* Jacq.) was sent from Denton, Texas, by Mr. W. H. Long, Jr., with the statement that *Æcidium Pteleae* B. & C., which has been taken to be the alternate form of the rust,[12] had not been observed in that vicinity. This material was sown on *Ptelea trifoliata* L., May 9, and spermogonia appeared May 15, followed by abundant aecidia May 24.

[9] Jour. Mycology **8**: 54. 1902.

[10] BOT. GAZ. **29**: 279. 1900, and Jour. Mycology **8**: 52. 1902.

[11] BOT. GAZ. **29**: 274. 1900. [12] BOT. GAZ. **29**: 273. 1900.

10. PUCCINIA HELIANTHI Schw.—Cultures showing this species to be autoecious have heretofore been made with American material only by Carleton[13], but have been reported from Europe. Teleutospores gathered in this vicinity on *Helianthus grosse-serratus* Mart. were sown on the same species of host with success (culture dates May 8, 17, and 23) and also on *H. Maximiliani* Schrad. (culture dates May 8, 16, and 22), but sowings at two different dates on *H. strumosus* gave no infection. This evidence of races, so far as it goes, does not accord with Carleton's opinion that "there is no distinction of host forms."

11. PHRAGMIDIUM SPECIOSUM Fr.—A successful culture[14] of this species of rust was again tried, using teleutospores from a hardy garden rose, obtained at Spirit Lake, Iowa, and sowing them on *Rosa humilis* Marsh. The culture was made April 24, and vigorous spermogonia appeared May 3, but the leaves gradually withered without the formation of the aecidial stage.

Beside the foregoing negative and confirmatory results, successful cultures were made establishing aecidial and teleutosporic association, heretofore unknown, for seven species of heteroecious grass and sedge rusts.

1. UROMYCES ARISTIDAE E. & E.—The material for the study of this species was received from Mr. W. H. Long, Jr., who suggested that its aecidial form was to be looked for on various species of Plantago. Teleutospores on *Aristida oligantha* Michx. were collected the middle of March, at Denton, Texas. Sowings were made from this material on *Plantago Rugelii* Dec., May 2, from which spermogonia arose May 13, and aecidia May 20. The development was not luxuriant, but very characteristic. A sowing on the same date on *P. lanceolata*, and later sowings on both species gave no infection. It would seem that these two species of Plantago are less suited to the ready development of the species than other members of the genus. The middle of April I received from Mr. Long freshly gathered aecidia on *Plantago virginica* L., and on two undetermined species, which are doubt-

[13] Science **13**: 250. 1901.

[14] For previous record see BOT. GAZ. **29**: 271. 1900.

less *P. Purshii* R. & S. and *P. aristata* Michx. I also have it in my herbarium on *P. virginica* from Illinois (Ellis and Everhart's N. Amer. Fungi, no. 1829), on *P. Purshii* from Nebraska (Fungi Columbiani, no. 1475), and on *P. eriopoda* Torr. from Montana, collected by F. D. Kelsey. The aecidium has passed under the name of *A. Plantaginis* Ces., but the identity with the European form needs verification, although microscopically the two are very similar.

2. PUCCINIA BARTHOLOMAEI Diet.—Again I am indebted to Mr. W. H. Long, Jr., for material and suggestions leading to the discovery of the aecidial connection of this host. Under date of April 8, 1902, he wrote: "I have never found *Puccinia vexans* in the state, although it is reported from Texas; *P. Bartholomaei* I have found, also its aecidial stage, which is *Aecid. Jamesianum* on *Asclepiodora decumbens*. I have never found this milkweed with aecidia on it, that I did not find teleutospores of *P. Bartholomaei* thickly covering the leaves of *Bouteloua curtipendula* around and under the milkweed, and the teleutospores when examined had germinated. Later the young grass in and near the bunches of infected milkweed would first show the rust; and where no teleutospores were found under or near the milkweed no aecidia were seen. This I observed repeatedly in my field work last year."

Mr. Long sent teleutospores on *Atheropogon curtipendulus* Fourn. (*Bouteloua curtipendula* Torr.), which were sown on *Asclepias incarnata* L. on May 2, giving rise to spermogonia May 8, and aecidia May 17. They were later sown with success on the same host (culture dates, May 21, 28, and June 5), and on *Asclepias syriaca* L. (culture dates, May 12, 18, and 26). They were also sown at two different dates on *Apocynum cannabinum*, with no infection.

As the specific name of the aecidium is older than that of the teleutosporic stage, the name of the fungus should become **Puccinia Jamesiana** (Pk.), nom. nov.

3. AECIDIUM IMPATIENTIS Schw.—The aecidium on Impatiens, and there appears to be but one, is very common throughout the eastern United States. It often occurs in a locality in the great-

est abundance, frequently affecting the leaves and stems of nearly every plant in a large area where the host may be growing thickly. Such a group of plants has been under observation for a number of seasons. In a space some twenty feet across, protected by a group of willows, many hundreds of *Impatiens aurea* Muhl. have sprung up from seeds each succeeding spring, and when from six inches to a foot high have become remarkably infested with aecidia. A rather large number of grass and sedge rusts occur in the vicinity of this spot, and the teleutospores of these have been sown in succession on Impatiens, and invariably with no infection. It was not until well into June of the present year that any clue was obtained. A tuft of *Elymus virginicus* L., growing at the edge of this patch of infested Impatiens, was found to possess young sori of some uredo. Searching further, dead leaves of the previous season were obtained bearing inconspicuous sori of what has generally been called *Puccinia rubigo-vera*, the teleutospores of which had already germinated. A collection on the same host was in the laboratory, however, that had been obtained early in the season from a locality some miles distant, which was still in germinating condition, Teleutospores from this were sown on *Impatiens aurea*, June 10, spermogonia following abundantly June 17, and aecidia June 25. Spores from the same collection had been sown previously on *Ambrosia trifida* and *Napaea dioica*, with no infection.

There are other creditable species of Puccinia on Elymus in the Rocky mountain and Pacific states, but this is the most common species and possibly the only one in the eastern states. It should be called **Puccinia Impatientis** (Schw.), nom. nov.

4. PUCCINIA SUBNITENS Diet.—I am indebted to Rev. J. M. Bates, of Callaway, Nebraska, for material to make the cultural study of this species, and for the suggestion which made the study fruitful. He wrote that wherever the grass rust occurred he had observed an aecidium on *Chenopodium leptophyllum* (Moq.) Nutt.

Teleutospores from *Distichlis spicata* (L.) Greene were sown on *Chenopodium album* L. on May 24, and on May 31 spermogonia appeared in the greatest luxuriance, followed by aecidia on June

3. A second sowing was made May 27, with spermogonia June 3, and aecidia June 9, in equal abundance. The crumpling of the leaves by the aecidia, and their bright orange color, made these the most striking cultures of the season. This aecidium is undoubtedly *A. Ellisii* Tr. & Gall., founded on a collection from New Mexico.

5. PUCCINIA AMPHIGENA Diet.—In the year 1883 the type collection for this species was made by the writer at Ravenswood, now a part of Chicago. The same season an aecidium was found on *Smilax herbacea* in the immediate vicinity,[15] which appeared to be *A. Smilacis* Schw. Owing to the limited distribution of these two forms, and their association within a seemingly restricted area, their possible genetic connection was thought worth testing. This opinion was strengthened by the fact that the grass rust has been collected a number of times since by the writer in the same locality, but no other aecidium has been found there at all likely to belong to it.

Teleutospores on *Calamovilfa longifolia* (Hook.) Hack., kindly sent by Rev. J. M. Bates from Callaway, Nebraska, were sown May 13 on both *Smilax herbacea* L. and *S. hispida* Muhl., and on May 20 both showed spermogonia, and May 31 aecidia. A second sowing on May 27 was only partially successful, as the leaves prematurely withered.

6. PUCCINIA SIMILLIMA Arth.—At the time of the publication of this species the writer called attention[16] to its probable connection with an aecidium on *Anemone canadensis*, which occurred in great abundance in the immediate vicinity.

Teleutospores on *Phragmites Phragmites* (L.) Karst. (*P. communis* Trin.), obtained by the writer from the type locality at Spirit Lake, Iowa, were sown on *Anemone canadensis* L., May 1, producing spermogonia May 5, and aecidia May 13. They were also sown, partly at the same time and partly later, on *Anemone cylindrica*, *A. virginiana*, *Pulsatilla hirsutissima*, and *Ranunculus septentrionalis*, all seemingly reasonable hosts, but with no infection. The aecidium has passed for *Aecid. Ranunculacearum*, but whether

[15] See BURRILL, Parasitic Fungi of Illinois 238.

[16] BOT GAZ. 34: 18. 1902.

it is distinct or not from the similar aecidia which have been found on the other hosts mentioned cannot now be stated.

7. AECIDIUM SOLIDAGINIS Schw.—Having found Puccinia teleutospores on *Carex Jamesii* Schw., they were sown on four species of Ribes, with no infection. They were then sown on six species of Aster, with no infection. At about the same time, May 9, they were sown on *Solidago canadensis* L., and followed by spermogonia May 15, and aecidia May 22. On May 24 a sowing was again made on *S. canadensis*, and also on *S. ulmifolia* Muhl., *S. caesia* L., *S. rigida* L., and *S. serotina* Ait., all of which produced spermogonia in ten to twelve days, but only the last developed aecidia. Part of these trials were repeated, and sowings also made on three additional species of Solidago, but without success. These failures appear to have been due chiefly to the feeble condition of the host plants.

A collection of Puccinia on *Carex stipata* Muhl., sent by Mr. E. W. D. Holway from Decorah, Iowa, was used for cultures on four species of Ribes, and on *Erigeron annuus* and *Onagra biennis*, with no infection. Afterward it was tried, May 27, on *Solidago canadensis*, giving spermogonia June 2 and aecidia June 9. On the same date it was sown on *S. serotina*, giving spermogonia June 2 and aecidia June 11.

As the specific name *Solidaginis* is already employed in the genus Puccinia, I propose for this species the name of **Puccinia Caricis-Solidaginis.** A comparison of this species with *P. Caricis-Asteris* and *P. Caricis-Erigerontis* shows many resemblances, and it seems not improbable that the three represent more correctly the biological variations of one species. However, in the many cultures so far made no set of teleutospores has been found that would infect more than one of the three host genera, Aster, Erigeron, and Solidago.

SUMMARY.

The following is a complete list of successful cultures made during the season of 1902. It is divided into the two series: species previously reported by the writer or other investigators, and species now reported for the first time.

A. SPECIES PREVIOUSLY REPORTED.

1. UROMYCES EUPHORBIAE C. & P.—Aecidiospores from *Euphorbia humistrata* Engelm, sown on same host. Aecidiospores from *E. nutans* Lag. sown on same host. Uredospores from *E. dentata* Michx. sown on same host.

2. UREDO RUBIGO-VERA DC.—Uredospores from *Triticum vulgare* Vill. sown on same host.

3. PUCCINIA PECKII (De T.) Kellerm.—Teleutospores from *Carex trichocarpa* Muhl. and *C. stipata* Muhl. sown on *Onagra biennis* (L.) Scop.

4. PUCCINIA SAMBUCI (Schw.) Arth.—Teleutospores from *Carex trichocarpa* Muhl. and *C. lurida* Wahl. sown on *Sambucus canadensis* L., and aecidiospores from *S. canadensis* L. sown on *C. trichocarpa* Muhl.

5. PUCCINIA CARICIS-ASTERIS Arth.—Teleutospores from *Carex foenea* Willd. sown on *Aster paniculatus* Lam.

6. PUCCINIA CARICIS-ERIGERONTIS Arth.—Teleutospores from *Carex festucacea* Willd. sown on *Erigeron annuus* (L.) Pers., *E. philadelphicus* L., and *Leptilon canadense* (L.) Britt.

7. PUCCINIA CARICIS (Schum.) Reb.—Teleutospores from *Carex stricta* Lam. and *C. riparia* Curt. sown on *Urtica gracilis* Ait.

8. PUCCINIA VERBENICOLA (K. & S.) Arth.—Teleutospores from *Sporobolus longifolius* (Torr.) Wood sown on *Verbena stricta* Vent. and *V. urticifolia* L.

9. PUCCINIA WINDSORIAE Schw.—Teleutospores from *Tricuspis seslerioides* (Michx.) Torr. sown on *Ptelea trifoliata* L.

10. PUCCINIA HELIANTHI Schw.—Teleutospores from *Helianthus grosse-serratus* Mart. sown on same host, and on *H. Maximiliani* Schrad.

11. PHRAGMIDIUM SPECIOSUM Fr.—Teleutospores from cultivated rose sown on *Rosa humilis* Marsh.

B. SPECIES REPORTED NOW FOR THE FIRST TIME.

1. UROMYCES ARISTIDAE E. & E.—Teleutospores from *Aristida oligantha* Michx. sown on *Plantago Rugelii* Dec.

2. PUCCINIA JAMESIANA (Pk.) Arth.—Teleutospores from *Atheropogon curtipendulus* (Michx.) Fourn. sown on *Asclepias incarnata* L. and *A. syriaca* L.

3. PUCCINIA IMPATIENTIS (Schw.) Arth.— Teleutospores from *Elymus virginicus* L. sown on *Impatiens aurea* Muhl.

4. PUCCINIA SUBNITENS Diet.—Teleutospores from *Distichlis spicata* (L.) Greene sown on *Chenopodium album* L.

5. PUCCINIA AMPHIGENA Diet.—Teleutospores from *Calamovilfa longifolia* (Hook.) Hack. sown on *Smilax herbacea* L. and *S. hispida* Muhl.

6. PUCCINIA SIMILLIMA Arth.—Teleutospores from *Phragmites Phragmites* (L.) Karst. sown on *Anemone canadensis* L.

7. PUCCINIA CARICIS-SOLIDAGINIS Arth.—Teleutospores from *Carex Jamesii* Schw. and *C. stipata* Muhl. sown on *Solidago canadensis* L. and *S. serotina* Ait., and also from the former Carex host sown on *S. caesia* L., *S. ulmifolia* Muhl. and *S. rigida* L.

It will not be out of place to emphasize again the desirability of making field observations upon the association of aecidial, uredo, and teleutosporic forms within small areas. There is little chance for progress in establishing the connection of spore-forms through cultural work, except by acting upon the hints derived from field notes. Any acute observer is likely to be able to make one or more important deductions of this kind during a season, which may lead to valuable discoveries upon testing by cultures. If collectors would bear the matter in mind, the perplexing tangle of our knowledge of the heteroecious rusts would soon largely yield to experimental study.

I cannot too heartily express my appreciation of the kindness of Professor W. A. Kellerman, Mr. W. H. Long, Jr., Rev. J. M. Bates, Dr. J. J. Davis, and Mr. E. W. D. Holway, for their assistance with material, and especially with suggestions derived from their field observations. Without such help much of the work recorded in this report could not have been undertaken.

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EXPERIMENTAL STUDIES ON INULASE.

ARTHUR L. DEAN.

IN 1888 J. Reynolds Green[1] reported the discovery of an inulin-splitting enzyme in the Jerusalem artichoke, *Helianthus tuberosus*. The tubers were planted and allowed to grow until the stems were about six inches above the ground. At that time the tissues of the tubers were found to have become much altered, being spongy in the middle part, although the outer part was still firm and contained inulin. A glycerine extract of these tubers was prepared and dialysed free from sugar. Such an extract was found to have the power to change inulin to a reducing sugar. Experiments were carried out in test-tubes and in dialysing tubes, with the result that Green was able to establish quite conclusively that the germinating artichoke contained an enzyme able to cause the hydrolysis of inulin. To this enzyme he gave the name "inulase." It is evident from Green's description that the extracts obtained by him were not very active. This he accounts for by supposing the enzyme to occur in very small quantities.

Some time before Green's paper appeared, Bourquelot had observed that *Aspergillus niger* grew well in media in which inulin was the only carbohydrate. Later, in 1893, he[2] published several short papers in which he recorded finding inulase in *Aspergillus niger*. The inulase was associated with several other enzymes, but Bourquelot was convinced that the cleavage of inulin was the function of a distinct ferment. In another paper[3] he compared the enzymes of *Penicillium glaucum* and *Aspergillus niger*, and notes the fact that inulase is present in the first-named fungus.

[1] On the germination of the Jerusalem artichoke (*Helianthus tuberosus*). Annals of Botany **1**: 223. 1888.

[2] Inulase et fermentation alcoholique indirecte de l'inuline. Compt. Rend. **116**: 1143. 1893. Also in Compt. Rend. Soc. Biol. IX. **5**: 481. 1893. Les ferments solubles d l'*Aspergillus niger*. Bull. Soc. Mycol. France **9**: 230. 1893.

[3] Remarques sur les ferments solubles sécrétés par l' Aspergillus et le Penicillium. Compt. Rend. Soc. Biol. IX. **5**: 653. 1893.

He says nothing concerning the inulase of Penicillium beyond the bare fact of its existence.

Chevastelon[4] was able to cause hydrolysis of the "inulin" from the monocotyledons by the agency of the inulase of Aspergillus.

It seemed of interest to investigate more fully the action of the inulase of Aspergillus and Penicillium, and to discover, if possible, whether or not it was identical with the inulase of the artichoke.

CULTURE METHODS.

Pure cultures of *Aspergillus niger* and *Penicillium glaucum* were obtained, and stock cultures kept on the following medium:

MEDIUM A.—Agar-agar, 10^{gm}; NaCl, 2.5^{gm}; peptone (Grübler's), 2.5^{gm}; beef extract, 1^{gm}; inulin (air dry), 5^{gm}; water, 500^{cc}.

The inulin used in making all culture media was prepared from *Dahlia variabilis* by alcoholic precipitation.

The first experiments were carried out upon Penicillium. A culture fluid having the following composition was prepared:

MEDIUM B.—Inulin, 1.5^{gm}; peptone (Grübler's), 0.5^{gm}; NaCl, 0.5^{gm}; beef extract, trace; water to make 150^{cc}.

Test-tubes containing this liquid were sterilized and inoculated with the spores of Penicillium. The fungus grew well in this medium. Each day the culture fluid of one tube was used to test for the presence of sugar (levulose) in solution. During the first three days no sugar reaction was evident, but after that time a reduction could be obtained by boiling the culture fluid with Fehling's solution. The amount of sugar was small at first, but steadily increased, until, after a week's time, the reaction was very marked.

Five days after inoculation the fluid from several cultures was filtered and heated in a water bath with phenyl-hydrazine hydrochloride and sodium acetate. The osazone formed separated while the solution was in the boiling water bath and had the characteristic crystalline form of glucosazone.

In order to establish the fact that the inulin of the medium was the source of the sugar formed, the following culture fluid was prepared which contained no organic compound except inulin:

[4] Sur l'inuline d'ail, de la jacinthe, d'asphodèle et de la tubereuse. Jour. Pharm. IV. 2: 1. 1895.

MEDIUM C.—Inulin, 5 gm; KNO_3, 0.5 gm; $CaCl_2$, 0.25 gm; Na_2So_4, 0.25 gm; NaH_2PO_4, 0.25 gm; $MgSo_4$, 0.2 gm; Fe_2Cl_6, trace; water to make 500 cc.

About 50 cc of this were placed in each of a number of small Erlenmeyer flasks, which, after sterilization, were inoculated with spores of Penicillium. As in the former case, so here, the fungus grew well, and its growth was followed after a few days by the appearance of a reducing sugar in the culture medium. After nine days of growth the culture fluid contained no inulin.

It was found that *Aspergillus niger* grown in the culture fluids described above caused, after a few days of growth, the same appearance of levulose in the solution. After trying a number of media the following was preferred as producing uniformly vigorous growths of the fungi:

MEDIUM D.—Inulin, 15 gm; peptone (Grübler's), 7.5 gm; KNO_3, 2 gm $CaCl_2$, 1 gm; Na_2SO_4, 1 gm; $MgSO_4$, 1 gm; NaH_2PO_4, 1 gm; $FeSO_4$, trace water to make 1500 cc.

This solution gave about equally good results when 25 cc were placed in small (125 cc) Erlenmeyer flasks, or when 75 cc were placed in larger (500 cc) flasks. Since the growth is almost entirely on the surface, a larger percentage of mycelia is obtained from a given quantity of culture medium if the fluid is in a thin layer. The cultures were grown in the dark at a temperature of 25–30° C.

METHOD OF OBTAINING PREPARATIONS OF INULASE.

Cultures of the fungi were grown as described above until about a week old; the mycelia were then filtered from the culture fluid, washed in distilled water, torn apart with needles, and thrown into a mixture of three parts of absolute alcohol and one part of ether. After remaining in the alcohol and ether about five minutes, the material was filtered off on a Büchner funnel and dried. The mass when ground to a powder yielded, in the case of Aspergillus, a black, and in the case of Penicillium, a grayish-green powder.

The above method was suggested by the procedure recommended by Albert[5] as a simple way to obtain the zymase from

[5] Einfacher Versuch zur Veranschaulichung der Zymase. Ber. Deutsch. Chem. Gesell. 33: 3775. 1900.

yeast. It has proved to be a good method for obtaining very active preparations of the invertin of yeast, and was therefore tried as a method for obtaining inulase from Penicillium and Aspergillus.

The Penicillium powder was examined first and was tested as follows. A few milligrams of the powder were ground with sand and water, and the mixture added to two test tubes containing a solution of inulin together with a little toluol. One of these tubes was boiled and both were placed in the incubator. After ten hours a very slight reducing power was observable in the unboiled solution. After forty-four hours equal quantities of the boiled and unboiled fluids were tested with the same quantity of Fehling's solution. The result was striking, there being a copious red precipitate of cuprous oxide in the test of the unboiled digestion, and a clear blue liquid in the other. Some of the liquid from the unboiled digestion was filtered and an osazone made. It was apparently glucosazone.

Experiments showed that this Penicillium powder would not yield a reducing sugar on auto-digestion, that it was without action upon a starch paste which was rapidly digested by saliva, but that it would invert cane sugar. The action of Penicillium powder on inulin, however, was not due to an ordinary invertin, since the invertin of yeast was found to be without action upon inulin.

The Aspergillus powder possessed a rather stronger inulin-splitting power than the Penicillium powder.

A number of attempts were made to obtain inulase from the culture fluids in which Penicillium and Aspergillus had been grown. The fluid itself, both before and after removal of the sugar by dialysis, failed to show any power to hydrolyse inulin. The precipitate thrown down in the culture fluid by alcohol contained no inulase. Attempts were made to make use of the well-known property of enzymes—of being carried down by precipitates of neutral salts formed in their solutions. Precipitates of barium sulphate, calcium sulphate, or calcium oxalate thrown down in portions of the culture fluid had no power to act on inulin. From these facts it is probable that

inulase acts inside the fungal hyphae and is not secreted into the surrounding medium. In this respect it resembles the zymase and endotrypsin of yeast, and like them belongs to the class of endo-enzymes.

INFLUENCE OF THE REACTION ON THE ACTIVITY OF INULASE.

It seemed desirable to ascertain whether the inulase found by Green in *Helianthus tuberosus* has the same properties as the inulase of the fungi; and whether or not the inulase of Aspergillus is identical with that of Penicillium. A thorough investigation of all the properties of these enzyme preparations has not been made. The most distinctive property given by Green is that alkalies are harmful to the inulase of artichoke, and that very dilute acids facilitate its action. To test the influence of the reaction of the solution upon the activity of the inulase of Aspergillus and Penicillium the following experiments were undertaken.

I. An inulin solution was made with 1.7569 ^{gm} of inulin dissolved in 155 ^{cc} of water containing a small amount of toluol. Of this solution 75 ^{cc} were placed in each of two flasks. To flask *A* were added 30 ^{cc} of a suspension of 1 ^{gm} of Aspergillus powder in 35 ^{cc} of water; to *B*, 30 ^{cc} of distilled water. Thirteen test-tubes were filled as follows:

No. 1. 10 ^{cc} from flask *A* [6] + 10 ^{cc} of 0.0002 normal H_2SO_4
No. 2. 10 ^{cc} from flask *A* + 10 ^{cc} of 0.002 normal H_2SO_4
No. 3. 10 ^{cc} from flask *A* + 10 ^{cc} of 0.02 normal H_2SO_4
No. 4. 10 ^{cc} from flask *A* + 10 ^{cc} of 0.1 normal H_2SO_4
No. 5. 10 ^{cc} from flask *A* + 10 ^{cc} of distilled water
No. 6. 10 ^{cc} from flask *A* + 10 ^{cc} of distilled water and boiled
No. 7. 10 ^{cc} from flask *A* + 10 ^{cc} of 0.0002 normal KOH
No. 8. 10 ^{cc} from flask *A* + 10 ^{cc} of 0.002 normal KOH
No. 9. 10 ^{cc} from flask *A* + 10 ^{cc} of 0.02 normal KOH
No. 10. 10 ^{cc} from flask *B* + 10 ^{cc} of 0.0002 normal H_2SO_4
No. 11. 10 ^{cc} from flask *B* + 10 ^{cc} of 0.002 normal H_2SO_4
No. 12. 10 ^{cc} from flask *B* + 10 ^{cc} of 0.02 normal H_2SO_4
No. 13. 10 ^{cc} from flask *B* + 10 ^{cc} of 0.1 normal H_2SO_4

Each tube was corked and allowed to stand at 35–37° C. for forty-five hours, at the expiration of which each was boiled and allowed to cool. All were filtered, the first few cubic centi-

[6] Before each 10 ^{cc} was removed, the flask was thoroughly shaken in order that equal quantities of the suspended powder might be taken each time.

meters of each filtrate being thrown away, and 10^{cc} analyzed for levulose by the ordinary gravimetric copper method. The acid solutions without inulase served as controls to show how much of the sugar formed was due to the enzyme and how much to the acid.

The results are given below :

No.	Inulase.	Reaction.	Mgms. levulose in 10^{cc}.	Mgms. levulose due to enzyme.
1	Added	0.0001 N. H_2SO_4	65.2	65.2
2	Added	0.001 N. H_2SO_4	41.6	33.8
3	Added	0.01 N. H_2SO_4	52.3	0
4	Added	0.05 N. H_2SO_4	50.5	0
5	Added	Neutral	53.1	53.1
6	Added	Neutral, boiled	....	0
7	Added	0.0001 N. KOH	25.3	25.3
8	Added	0.001 N. KOH	20.0	20.0
9	Added	0.01 N. KOH	....	0
10	Not added	0.0001 N. H_2SO_4	....	....
11	Not added	0.001 N. H_2SO_4	7.8	....
12	Not added	0.01 N. H_2SO_4	50.4	....
13	Not added	0.05 N. H_2SO_4	49.5	....

II. The sixteen test tubes used in this experiment were filled in a way similar to that in experiment I. Each tube was corked and kept for twenty-one hours at 35–37° C. At the expiration of that time the fluid containing acid were neutralized with barium carbonate in substance. All were then boiled, filtered, and made up to 50^{cc}, of which 25^{cc} were analysed in each case. Following are the results :

No.	Inulase.	Reaction.	Mgms. levulose.	Mgms. levulose due to enzyme.
1	Added	0.0001 N. H_2SO_4	35.2	35.2
2	Added	0.0002 N. H_2SO_4	28.9	28.9
3	Added	0.001 N. H_2SO_4	23.2	23.2
4	Added	0.01 N. H_2SO_4	38.8	0
5	Added	0.05 N. H_2SO_4	59.0	0
6	Added	Neutral	27.5	27.5
7	Added	Neutral boiled	....	0
8	Added	0.0001 N. KOH	26.9	26.9
9	Added	0.001 N. KOH	7.0	7.0
10	Added	0.01 N. KOH	....	0
11	Added	0.05 N. KOH	....	0
12	Not added	0.0001 N. H_2SO_4	....	....
13	Not added	0.0002 N. H_2SO_4	....	....
14	Not added	0.001 N. H_2SO_4	....	....
15	Not added	0.01 N. H_2SO_4	39.3	....
16	Not added	0.05 N. H_2SO_4	59.2	....

III. Considerable difference is shown between the two tables in regard to the effect of the presence of 0.0001 normal potassium hydroxide in the solution. Therefore the following experiment was tried. To a solution of inulin Aspergillus powder was added and the fluid shaken. Of this suspension 10^{cc} were measured into each of two test tubes; to one 10^{cc} of 0.0002 normal KOH were added, and to the other 10^{cc} of distilled water. Three drops of thymol solution were added to each. After shaking, both were corked and kept in the incubator for fifty-four hours. At the end of that time the solutions were filtered and analyzed for levulose. Solution containing 0.0001 N. KOH gave 32.0^{mgms}; neutral solution gave 36.6^{mgms}.

IV. Experiment IV was tried with the inulase from *Penicillium glaucum*. The solutions were made up and the tubes filled in a way similar to that in experiments I and II. Each tube, after the addition of five drops of thymol solution, was corked and kept at 38–40° C. for seventy-one hours. At the end of that time the solutions containing acid were neutralized with barium carbonate and all were boiled. After cooling they were filtered through dry filters and each residue washed with 10^{cc} of distilled water added in two portions of 5^{cc} each. The filtrate and wash water were united in each case and 25^{cc} of the solution analyzed for levulose. The results are given in the table below.

No.	Inulase.	Reaction.	Mgms. of levulose in 25^{cc}.	Mgms. of levulose due to enzyme.
1	Added	0.0001 N. H_2SO_4	98.5	98.5
2	Added	0.001 N. H_2SO_4	61.5	31.2
3	Added	0.01 N. H_2SO_4	114.5	....
4	Added	Neutral	71.4	71.4
5	Added	Neutral, boiled	....	....
6	Added	0.0001 N. KOH	64.6	64.6
7	Added	0.001 N. KOH	19.1	19.1
8	Added	0.01 N. KOH	....	....
9	Not added	0.0001 N. H_2SO_4	....	....
10	Not added	0.001 N. H_2SO_4	30.3	....
11	Not added	0.01 N. H_2SO_4	116.0	....

V. In order to ascertain whether the enzyme is destroyed, or only inhibited, by the action of acids and alkalies the following

experiment was tried. Four test tubes were filled as follows, the inulin solution used containing Aspergillus powder in suspension:

No. 1. 10^{cc} inulin solution + 10^{cc} of 0.02 N. H_2SO_4
No. 2. 10^{cc} inulin solution + 10^{cc} of 0.1 N. H_2SO_4
No. 3. 10^{cc} inulin solution + 10^{cc} of 0.02 N. KOH
No. 4. 10^{cc} inulin solution + 10^{cc} of 0.1 N. KOH

Each tube was corked and placed in the incubator for twenty-four hours, at the expiration of which the solutions were neutralized; each solution was divided into two parts, one of which was boiled. The resulting eight solutions were kept in the incubator for ten days and then examined for levulose. In no case was more sugar present in the unboiled than in the boiled solution. We may conclude, therefore, that the enzyme had been destroyed in each test.

From an examination of the results of the experiments detailed above, it is evident that the optimum reaction for the inulase of *Aspergillus niger* and of *Penicillium glaucum* is very close to 0.0001 normal acid (sulphuric). This corresponds well with Green's statement concerning the inulase from Helianthus, which, he says, "works most advantageously in a neutral or very faintly acid medium, the best proportion of acid being about 0.001 per cent. of hydrochloric acid." Green also says that "alkalies are deleterious," a fact which agrees with the results of the experiments on inulase from Aspergillus and Penicillium. The reaction of the fluid seems to have the same effect on the enzyme obtained from each of the two fungi.

INFLUENCE OF THE TEMPERATURE ON THE ACTIVITY OF INULASE.

In his recent book on the enzymes Effront[7] states that "the optimum temperature of inulase is found between 50 and 60°." He gives no authority for the statement, neither does he bring forward any experimental evidence. Bourquelot says that inulase survives a temperature of 64°, but makes no statement in regard to its optimum working temperature. Green states that inulase acts better at 40° than at room temperature, but loses its activity at between 70 and 80°. The unusually high temperature given

[7] Enzymes and their application. Translated by Samuel C. Prescott. pp. 249–251. New York. 1902.

by Effront seemed worthy of investigation, and accordingly the following experiments were undertaken to ascertain the optimum temperature for the inulase of *Aspergillus niger*.

I. About 1^{gm} of a very active preparation of Aspergillus powder was extracted for 24 hours in 50^{cc} of water containing a little thymol. The extract was then filtered and added to a solution of about 1^{gm} of inulin and the mixture made up to 150^{cc}. Of this solution 20^{cc} were added to each of seven test-tubes and two drops of toluol added to each tube. All the tubes were corked and kept at the temperatures given below for five hours, at the expiration of which period all were boiled and 15^{cc} from each tube analyzed for levulose with the results given below:

Temperature.	Mgms. of levulose.
10°	37.2
20°	45.4
30°	59.6
40°	78.5
50°	93.1
60°	108.7
70°	38.1

II. One gram of Aspergillus powder was extracted for twenty-four hours in 50^{cc} of water containing a little toluol. The extract was then filtered and added to a solution of 1.7^{gm} inulin in 100^{cc} of water and the mixture then made up to 200^{cc}. Of this solution, 20^{cc} were added to each of eight test-tubes and three drops of toluol added to each tube. Number 8 was then boiled. They were all corked and kept for seven hours at the temperatures given below, at the expiration of which period all were boiled and 15^{cc} from each tube analyzed for levulose with the results given below:

No.	Temperature	Mgms. of levulose
1	20°	13.2
2	30°	18.8
3	40°	21.1
4	50°	29.6
5	60°	26.4
6	65°	11.3
7	70°	10.2
8	50° boiled	8.8

III. One gram of Aspergillus powder was extracted for twenty-four hours in 50 cc water containing a little toluol. The extract was filtered and added to a solution of 1.1 gms of inulin in 40 cc of water and the resulting mixture made up to 100 cc. Of this solution 20 cc were added to each of five test tubes and three drops of toluol added to each tube. Number 5 was then boiled. All were corked and kept at the temperatures given below for six hours, at the expiration of which all were boiled and 15 cc from each tube analysed for levulose with the results given below.

No.	Temperature	Mgms. of levulose
1	40°	42.2
2	50°	55.5
3	60°	51.8
4	65°	19.9
5	50° boiled	20.9

In the first series of tests the optimum temperature was nearer 60° than 50°, but in the second and third series it was nearer 50°. It is noticeable that in the first series of tests the enzyme was evidently present in much larger quantity than in any of the subsequent digestions. In order to discern whether or not the difference in the effect of the temperature was due to a difference in the concentration of the enzyme the following trial was made:

IV. In flask *A* one gram of Aspergillus powder was extracted in 50 cc of water plus toluol. In flask *B* 2.5 gms of Aspergillus powder were extracted in the same quantity of water. Both extracts were filtered and added to 75 cc of the same inulin solution; toluol was added to each, and each solution made up to 150 cc. Two series of six test-tubes each were filled from the two solutions, 25 cc being placed in each tube. The tests were kept at the temperatures given below for six hours, then boiled, and 20 cc from each was analyzed for levulose.

From the results detailed below it appears that the optimum temperature for inulase lies very near to 55°. There is an indication that in more concentrated solutions the optimum temperature is slightly higher. It is a well-known fact that the presence

SERIES A.—Extract from 1^{gm} Aspergillus powder.

Temperature	Mgms. of levulose
40°	22.5
50°	27.1
55°	29.3
60°	25.7
65°	14.7
55° boiled	11.7

SERIES B.—Extract from 2.5^{gms} Aspergillus powder.

Temperature	Mgms. of levulose
40°	59.4
50°	70.6
55°	74.2
60°	71.9
65°	44.9
55° boiled	33.2

of foreign substances—inorganic salts, proteids, etc.—in the solution in which an enzyme is acting will tend to raise the temperature at which destruction of the enzyme takes place, and in many cases to raise its optimum working temperature.[8] It will be of interest to discover whether or not inulase prepared by a more careful method, by which the bulk of all impurities is eliminated, will show a much lower optimum temperature and range itself with those enzymes which act best at about 40° C.

SUMMARY.

1. In confirmation of the results of Bourquelot, inulase was found in the fungi *Aspergillus niger* and *Penicillium glaucum*.

2. The inulase of these fungi does not pass into the culture medium; it is therefore an endo-enzyme.

3. The preparations of inulase from Aspergillus and Penicillium show similar variations in activity due to changes in the reaction of the medium. The enzyme acts most vigorously in a medium containing 0.0001 normal acid (H_2SO_4); greater

[8] Cf. CHITTENDEN: On digestive proteolysis. pp. 18, 19. New Haven. 1895.—PUGLIESE: Ueber den Einfluss der Erwärmung auf diastatische Fermente. Archiv Gesamm. Physiol. **69**: 115. 1898.

strengths of acids are unfavorable, the enzyme being destroyed by 0.01 normal sulphuric acid. Alkalies hinder the activity of inulase, even 0.0001 normal potassium hydroxide being injurious; 0.01 normal potassium hydroxide destroys the enzyme.

4. The optimum temperature for inulase was found to be about 55° C.

In conclusion, I wish to express my great indebtedness to Professor Lafayette B. Mendel for his able assistance in all parts of this work.

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YALE UNIVERSITY.

THE DISTRIBUTION OF THE UPLAND PLANT SOCIETIES OF KENT COUNTY, MICHIGAN.[1]

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. XLIII.

BURTON EDWARD LIVINGSTON.

(WITH MAP)

INTRODUCTION.

1. CLIMATOLOGY OF THE COUNTY.—Kent county is so situated that it is traversed both by the southern boundary of the pine-forest region and the eastern boundary of the so-called Michigan peach belt. It is also crossed by the Grand River valley, the line of one of the great main channels by which the melting ice of the glacial period reached the Mississippi system and the Gulf, and also the line marking the farthest northern extension within the peninsula of many typically southern plants. The county embraces a rectangular tract of land 38.6^{km} by 57.9^{km} in extent. Its western boundary is a meridian averaging about 37^{km} east of Lake Michigan at its widest part. Lacustrian influence upon the climate is probably felt throughout the county. Owing to the comparatively small extent of area, differences in climate between its different parts could hardly be pronounced enough to cause any marked difference in its vegetation. Also on account of the great distance apart of the stations for meteorological observations, if there were less differences between the climates of different portions of the county, such would not be brought out by any records which have been made. Therefore, a study of these meteorological data can hardly give any clue to the principles underlying plant distribution within the area.[2]

[1] A less technical account of the survey here presented was published in the Annual Report of the State Board of Geological Survey of Michigan, 1901, pp. 81–103, and it is through the courtesy of Dr. A. C. Lane, state geologist, under whose auspices the work was done, that the present account is published.

[2] Tables of the average temperature and precipitation by months for this region, compiled from the reports of the Michigan section of the U. S. climate and crop service, are to be found in the author's former publication, *loc. cit.*

The range of altitude over the whole county is less than 122^{m}, so that absolute altitude itself, with its concomitant variations in climatic conditions, is not a factor in the distribution of the flora. Differences in *relative* level, however, produce marked variations in the drainage, and hence in the water content of the soils.

2. GEOLOGY OF THE COUNTY.[3]— The bed rock of the area is almost entirely covered to a great depth by glacial drift, only a few small outcrops being found within its limits. The drift is so deep throughout the county that the underlying rock layers have apparently no influence upon the vegetation. But the drift itself presents some very interesting features.[4] The land consists, in general, of two great blocks of till upland lying on either side of a much lower gravel and sand plain of varying width, which extends in an irregular line from about the middle of the northern boundary southward through Cedar Springs, Rockford, Plainfield, Grand Rapids, Fisher, Carlisle, and Ross, and cutting the southern boundary about 4.8^{km} east of the southwest angle of the county. This plain traces the path of the outflowing water as the Michigan ice sheet retreated northward at the end of the last glacial epoch. An indentation or embayment in the southern ice margin during this retreat marked the junction of the two lobes of the glacier, the eastern lobe coming from the region of Saginaw Bay, the western from that of Lake Michigan. It was naturally into this embayment that much of the water was discharged during the melting process, and the line of sandy plains just traced marks, from Carlisle northward, the path of this gradually increasing notch in the edge of the ice. Southward of Carlisle the Green Lake sand and gravel plain (in Allegan and Barry counties) originated in the same way.

Three well-marked terminal moraines lie partly within the

[3] For a more detailed account of these features, see the author's previous publication on the same subject, already cited. A brief description of these features, by Dr. A. C. Lane, will be found in the introduction to MISS E. J. COLE'S *Grand Rapids Flora*, Grand Rapids, 1901.

[4] For aid in interpreting the glacial topography I am indebted to Mr. Frank Leverett, of the U. S. Geological Survey.

area. The southernmost, and hence earliest formed of these, follows roughly a line drawn through Ross, Carlisle, Middleville, and Hastings. The second passes through the middle of the county, the southern edge being now the northern boundary of the Grand River valley. The third moraine has its highest point northeast of Cedar Springs, and extends in an irregular and broken manner southeastward to the vicinity of Harvard, and northward and westward to Kent City and Casnovia. The second moraine is broken through by the valley of the Rouge River, and the third by the same valley and also by the sand plain north of Cedar Springs. These moraines are usually bordered by sand plains on the outwash side and by till plains on the side which was toward the ice sheet.

Most of the surface soil of the county is predominantly sandy. In classifying soils and designating them on the map, no attempt has been made to distinguish the different gradations between clay and sand. All soils which could not be termed either clay or sand have been bunched together as loam, in the broadest sense of that word, and denoted on the map by dots. More accurate records were made, but it was found that these minor differences of soil bore no apparent relation to the nature of the societies recorded, and it was thought best not to encumber the map with unnecessary details. Clay is denoted on the map by horizontal lines, sand by an absence of any marking. Sand and gravel plains of limited extent lie along almost every creek and about many of the lakes. No attempt has been made to map these smaller deposits.

3. METHODS.—Owing to the large proportion of cultivated land in the county, and the correspondingly small proportion which is in an approximately natural state, a study of the natural plant societies is necessarily a difficult one. From the more or less natural areas which still remain, an attempt has been made to reconstruct, as accurately as possible, the plant societies which occupied the region at the time of settlement. The effects of pasturing in wood lots have been allowed for so far as possible. Information has been gathered from local residents as to the nature of the forest which was removed in making certain fields

ready for the plow, and this information has been of great service in some instances.

The vegetation of the area falls naturally into two groups, that growing on what is commonly termed dry ground and that found in moist or swampy places. Each of these groups can be separated into several societies, which often merge gradually into one another, so that in some localities it appears that there is a mixture of several of them. But in general the division is sufficiently well marked. In the present paper attention will be confined to the upland group.[5]

THE PLANT SOCIETIES.

1. Classification.— The vegetation of the upland falls into five societies, which may be characterized as follows:

I. *Beech-maple society*, comprising as predominant and characteristic the following plants: beech, sugar maple, enchanter's nightshade (Circaea), wild licorice (*Galium lanceolatum*), wood nettle (Laportea), catnip (Nepeta), pokeweed (Phytolacca), richweed (Pilea), nightshade (*Solanum nigrum*), and red-berried elder.

II. *Maple-elm-agrimony society*, comprising sugar maple, American and rock elms, agrimony, spikenard (*Aralia racemosa*), honewort (Cryptotaenia), spice-bush (Lindera), moonseed (Menispermum), black snake-root (Sanicula), and wild black cherry.

III. *Oak-hickory society*, comprising white and red oak (*Quercus rubra coccinea*), shag-bark and pig-nut hickory, false Solomon's seal (*Smilacina racemosa*), northern bedstraw (*Galium boreale*), *Aster laevis*, and panicled cornel. This society is much the same as the following, but with the addition of the two hickories. It also has many plants in common with the previous society, and may be regarded as an intermediate type between II and IV, both of which are much more distinct. Owing to the difficulty of distinguishing sharply between *Quercus coccinea* and *Q. rubra*, these two forms have been brought together under the name *Q. rubra coccinea*.

[5] The study of the lowlands was not thorough. The reader will find a general statement of the lowland conditions in the previously published account, *loc. cit.*

IV. *Oak-hazel society*, comprising white and red oaks, *Aster laevis*, *A. macrophyllus*, New Jersey tea, hazel, spurge (Euphorbia), *Helianthus occidentalis*, *Solidago caesia*, and hoary pea (Tephrosia). The spurge found in this society is the broad-leaved form. In the following society this plant is just as common and characteristic as here, but there it has much narrower leaves. The individuals of the broad-leaved form appear stronger, greener, and more robust than the others.

V. *Oak-pine-sassafras society*, comprising white and red oaks, white pine, sassafras, plantain-leaved everlasting (Antennaria), wormwood (Artemisia), sand bur, spurge (narrow-leaved form), huckleberry (Gaylussacia), lupine, sweet fern, bracken, and *Solidago nemoralis*. This includes the dryest and most open form of "oak openings," together with the country which was once quite well covered with pine. They are put together here, because, aside from the now partially extinct white pine, the floras are practically the same.

A more extensive list of plants is given in the following table, which shows almost graphically the distribution of the enumerated plants throughout the five societies. The nomenclature is that of the sixth edition of Gray's *Manual*. The Roman numerals heading the five columns at the right of the names indicate the societies by number, the same method of indication being also adopted on the map. The letters opposite the plant names show in what societies the plant occurs, the relative abundance in that society being denoted by the letter itself. C denotes common: F, frequent; R, rare. An asterisk accompanying the letter expresses the fact that the plant is one of those to be regarded as specially characteristic of that society. Our *rare* has not the meaning given the word by the systematist; plants which he would consider rare are not sufficiently abundant to be considered at all in such a list as the present.

2. **Distribution.**—The distribution of the societies is shown on the map. From the darkest to the lightest of the five shades used a gradation is shown corresponding to that in the societies from I to V. The sixth and lightest shade denotes deeply-eroded channels occupied chiefly by lowland societies. In these

TABLE OF THE UPLAND PLANT SOCIETIES.

Species	Common name	I	II	III	IV	V
Acalypha virginica	Three-seeded mercury	F	F			
Acer rubrum	Red or swamp maple	R	F	R		
Acer saccharinum	Sugar or rock maple	C*	C	R		
Actaea alba	White baneberry	F*				
Adiantum pedatum	Maidenhair fern	...	F			
Agrimonia Eupatoria	Agrimony	...	C*	F		
Andropogon furcatus	Beard grass	...	...	...	...	C*
Antennaria plantaginifolia	Plantain-leaved everlasting	...	...	...	...	C*
Aralia racemosa	Spikenard	...	C*	F		
Artemisia caudata	Wormwood	...	...	...	...	C*
Aspidium acrostichoides	Christmas fern	F*				
Aster cordifolius		F	C	C		
Aster laevis		...	...	C	C*	
Aster macrophyllus		...	...	F	C*	
Boehmeria cylindrica	False nettle	C*	F	R		
Carpinus caroliniana	Blue or water beech	...	C*			
Carya alba	Shag-bark hickory	...	F	C*	R	
Carya porcina	Pig-nut hickory	...	F	C*	R	
Ceanothus americanus	New Jersey tea	...	...	R	C*	F
Cenchrus tribuloides	Sand bur	...	...	...	...	F*
Chimaphila umbellata	Prince's pine	...	...	R	R	F*
Circaea Lutetiana	Enchanter's nightshade	C*	R			
Cornus alternifolia	Alternate leaved cornel	...	C	C		
Cornus florida	Flowering dogwood	...	C	F		
Corylus americana	Hazel	...	...	F	C*	F
Cryptotaenia canadensis	Honewort	...	C*	F		
Cynoglossum virginicum	Hound's tongue	F*	R			
Diervilla trifida	Bush honeysuckle	...	...	...	F	C*
Dracocephalum parviflorum	Dragon head	F*				
Echinospermum virginicum	Beggars lice	C*	R			
Epigaea repens	Trailing arbutus	...	...	...	...	F*
Epiphegus virginiana	Beech drops	C*				
Euphorbia corollata	Spurge	...	...	F[6]	C[6]	C*[7]
Fagus ferruginea	American beech	C*	R			
Galium boreale	Northern bedstraw	...	F	C*		
Galium circaezans	Wild licorice	F*	R			
Galium lanceolatum	Wild licorice	C*	R			
Gaultheria procumbens	Wintergreen	...	...	...	F	C*
Gaylussacia resinosa	Black huckleberry	...	...	...	F	C*
Gerardia quercifolia	Smooth false foxglove	...	...	F	F	F
Geum album	Avens	...	C*	R		
Hedeoma pulegioides	American pennyroyal	F*				
Helianthus divaricatus	Sunflower	...	R	F	C	C*
Helianthus occidentalis	Sunflower	...	...	F	C*	F
Hepatica acutiloba	Liverleaf	C	C*	C		
Hepatica triloba	Liverleaf	...	...	C	C*	
Hieracium scabrum	Hawkweed	...	...	F	F	C*
Juglans cinerea	Butternut	...	F	R		
Juglans nigra	Black walnut	...	F	R		
Laportea canadensis	Wood nettle	C*	F			
Lechea minor	Pinweed	...	...	...	...	C*

[6] Broad-leaved form. [7] Narrow-leaved form.

TABLE OF THE UPLAND PLANT SOCIETIES—*continued.*

Species	Common name	I	II	III	IV	V
Lespedeza polystachya	Bush clover	...	...	...	F.	C*
Lespedeza Stuvei intermedia	Bush clover	...	...	...	...	C*
Liatris cylindracea	Blazing star	...	...	...	...	C*
Liatris scariosa	Blazing star	...	...	...	...	C*
Lindera Benzoin	Spice bush	...	C*			
Lobelia inflata	Indian tobacco	C*	R			
Lupinus perennis	Wild lupine	...	...	...	R	C*
Medeola virginiana	Indian cucumber root	F*				
Melampyrum americanum	Cow wheat	...	...	...	F	F*
Menispermum canadense	Moonseed	...	C*	F		
Monarda fistulosa	Wild bergamot, horse mint, balm	...	...	F	F	C*
Monarda punctata	Horse mint	...	...	...	...	F*
Myrica asplenifolia	Sweet fern	...	...	...	...	C*
Nepeta Cataria	Catnip	C*				
Onoclea sensibilis	Sensitive fern	...	F*			
Ostrya virginica	Ironwood	...	C	C		
Phlox subulata	Moss pink	...	...	...	...	F*
Phryma Leptostachya	Lopseed	...	F*	R		
Physalis virginiana	Ground cherry	...	...	...	...	C*
Phytolacca decandra	Pokeweed	C*				
Pilea pumila	Richweed	C*				
Pinus Strobus	White pine	...	...	...	F	C*
Polygonatum giganteum	Solomon's seal	...	C	F		
Populus grandidentata	Large toothed aspen	...	...	...	...	C*
Prenanthes alba	Rattlesnake root	...	R	F	C*	
Prunus serotina	Wild black cherry	...	F*			
Prunus virginiana	Choke cherry	...	...	F	C*	
Pteris aquilina	Braken	...	...	...	F	C*
Pyrola elliptica	Shinleaf	...	...	...	...	F*
Quercus alba	White oak	...	R	F	C*	C*
Quercus ilicifolia	Black scrub oak	...	...	...	...	F*
Quercus rubra-coccinea	Red or black oak	...	R	F	C*	C*
Rhus copallina	Dwarf sumach	...	...	...	R	F*
Ribes Cynosbati	Gooseberry	C*	F			
Rudbeckia hirta	Browneyed Susan	...	...	R	R	C*
Sambucus racemosa	Red berried elder	C*	R			
Sanicula marylandica	Black snake-root	...	C*	F		
Sassafras officinale	Sassafras	...	...	R	R	C*
Smilacina racemosa	False Solomon's seal	...	C	C		
Smilax hispida	Greenbrier	...	F	R		
Solanum nigrum	Nightshade	C*				
Solidago bicolor concolor	Goldenrod	...	...	F	F	C*
Solidago caesia	Goldenrod	...	...	F	C	C
Solidago nemoralis	Goldenrod	...	...	...	...	C*
Solidago rugosa	Goldenrod	...	C*	F		
Tephrosia virginiana	Hoary pea	...	...	R	C*	C
Tilia americana	Basswood	C	C	F		
Ulmus americana	White or American elm	R	C*	F		
Ulmus racemosa	Rock elm	R	C*	F		
Vaccinium canadense	Blueberry	...	...	F	C	C
Vaccinium pennsylvanicum	Dwarf blueberry	...	...	F	C	C
Vicia caroliniana	Vetch	...	F	C*	C	
Vitis cordifolia	Frost grape	...	C	C		

UPLAND PLANT SOCIETIES
KENT CO., MICHIGAN.

channels the areas occupied by the different societies are so limited that any satisfactory representation of them on the scale of the present map was deemed impossible. Therefore they are left unshaded. Also the lowland societies along the margins of smaller streams and lakes and in swamps among the hills are omitted entirely from the map. The reason for this is in part the same as the one given for the larger channels, and also in part this, that although some of the swamps are large enough to map well on the present scale, yet to trace their margins accurately would require more time than it would be worth, and to map them inaccurately would not be true to the instinct of the work.

Steep slopes where erosion is at present rapid, as along the margins of the many stream valleys and along old glacial channels, are occupied by societies III, IV, and V. The character of the soil seems to make no difference here, the drainage being quite complete and the accumulation of humus impossible. It has also been found impracticable to indicate these very narrow areas upon the map.

In the southern tier of townships, all the heavy clay soil, whether it be rolling moraine or level till plain, was originally occupied by the beech-maple society (I). In the lighter loamy soils are usually found the oak-hickory society (III), with transition zones between it and I held by the maple-elm-agrimony society (II). The very sandy loam bordering the deep narrow valley of the Thornapple River, and spreading eastward from Alaska and Labarge nearly to the Elmdale till plain, is occupied by the oak-hazel and the oak-pine-sassafras societies (IV and V). This loam is in many places as sandy as the soil of the Grand River sand plain; it might almost have been denoted as sand.

Within the "big bend" of the Grand River is an area of decidedly clayey country occupied by the oak-pine-sassafras society (V), although here the pine is not at all prominent. It appears as though this area were well on the way toward society IV at the time of clearing. But the marked presence of sassafras, wormwood, sand bur, *Solidago nemoralis*, and other forms of society V, makes it impossible to classify it elsewhere.

The Grand Rapids sand plain (reaching from Rockford, through Plainfield and Grand Rapids to Grandville and Ross) is generally covered with societies IV and V. The foundation soil is apparently the same throughout, being a gravelly sand, but the areas of society IV have undoubtedly more surface humus, thus giving the soil a darker color and a more loamy texture. The higher parts of the plain, and hence the portions which have been out of water longest, are generally the portions which show this condition. The lower portions where violent water action probably continued after the main stream receded, and where, owing to the slope, erosion is even now well marked, bear little surface humus and are characterized by society V. Here, at the time of clearing, the pine was usually present. Transition areas between IV and V were covered with "oak openings," however. Much of these channel areas is swampy and hence thrown out of the present discussion.

North of Grand River it is only in the western column of townships that the heavy clay is characteristically covered with society I. In other portions of the region the clay is mainly covered with society III, IV, or V. It will be noticed that clay which bears the oak-pine-sassafras society is common in the extreme north and becomes less common southward. Societies III and IV approach each other in character as we pass northward. The hickories become less frequent and the general aspect of III becomes more that of IV. It needs to be remarked here also that the stretch of society III, reaching from the Rouge River southward and lying west of Grand Rapids, is a curious mixture of II and IV. Judging from the trees alone, the southern part of it should be placed in society II, but the presence of New Jersey tea, *Solidago caesia*, etc., seems to place it in the oak-hazel group. Sassafras is present here to a remarkable extent, and in many places, especially to the north, white pine also. The northern part of this stretch contains much pine. Altogether, the area can better be classified under III than otherwise. In the general discussion to follow the possible reasons for the mixing will be considered.

In the bit of beech-maple society in the extreme north-

western part of the county is found the only marked instance of the presence of hemlock. This tree belongs typically with the hard wood group in northern Michigan.

In the northern part of the county white pine was almost universally present in the uplands at the time of settlement. This can be proven by stumps which are still in place or have been used in the construction of stump fences. There are pine stumps and a few trees still standing even in the beech-maple group upon areas north of an east and west line drawn through a point about midway between Cedar Springs and Rockford. South of this line the pine disappears in society I and becomes very rare in all but IV and V.

3. Generalizations on the upland flora.—Any sort of generalization upon the study of such a limited area as the present must necessarily be a hazardous undertaking. I venture to call attention to the following points, however, all of which must be looked upon as merely tentative suggestions:

a. *The soil factor.*—It appears that the general distribution of the upland societies is based primarily upon the nature of the superficial soil. This must be so, since the roots of the smaller plants never penetrate very far into the soil, and since, in the case of trees and shrubs seed germination and the growth of seedlings is conditioned by the surface layers. If seedlings cannot develop it is clear that there can be no mature plants.

It is very probable that the original till material covering Kent county was reasonably uniform in chemical constituents. That it was thoroughly mixed by the movement of the ice sheet is shown by the wealth of different minerals to be found in any small region. In spite of the marked washing, the most sandy soils contain a considerable amount of minerals other than silica.[8] The plant can make use of the soil constituents only after they are in aqueous solution. The great bulk of the soil is practically insoluble in water, and it makes no difference to the plant what may be the chemical nature of these undissolved substances. Thus it would seem much more to the point to make

[8] KEDZIE, R. C., Analysis of soil of jack-pine plains near Grayling, Michigan. Annual Report Mich. Board of Agriculture **27**: 211. 1888; also Bull. 99, 1893.

analyses of the soil water, for it is this which affects the plant directly. Such analyses were not made in connection with the present work, but it is hoped that they will be made at some future time, either for this region or some similar one. It is very probable, however, that soil waters from the surface soil in different parts of this area will be found to be very nearly uniform in the salts contained. This conclusion results from two considerations: first, the chemical nature of the soluble part of the surface soil itself is very nearly uniform throughout the county; second, the washed soils are usually comparatively shallow, and upward diffusion of dissolved substances probably takes place with comparative rapidity, especially when aided by the soil currents produced by changes of temperature, evaporation, etc. The only localities where it is at all probable that a paucity in soluble salts will be found to occur in the soil water are the deep sand plains. There is some rather questionable evidence from the vegetation that such is the case in these localities, but as yet no definite decision can be made in this regard.

In classifying soils according to their physical nature, the only question which has any direct bearing upon plant growth is that of the ability of the soil to retain water by capillarity, so-called. Primarily, this ability depends upon the size of the soil particles. Thus sand will retain less water than will loam, and loam will retain less than clay. Sandy soil may be made to retain more water in two different ways, either by the addition of clay or by the addition of humus. The physical effect of humus is very well marked. Of course the humus also adds some nitric acid and certain organic materials which are of benefit to the plant, and it also increases the amount of soluble salts at or near the surface; for humus is formed mainly from leaves, and in these organs the mineral part of the plant body is concentrated. This is perhaps an important fact in the growth of hard wood upon deep sand which is well covered with humus. Where drainage is complete and rapid, as in sand, and oxidation is also rapid, humus does not readily accumulate; but where it does accumulate as a surface layer, the ability of the soil to retain water approaches that of clay.

From the present study it appears that the most important soil factor in the distribution of the flora of Kent county is this one of the relative ability of the superficial layers to retain water. In other words, *the controlling soil condition is one of drainage*.

Throughout the southern half of the county, soils which retain much water are covered with society I, II, or III. The only exception to this is the small clay area within the bend of Grand River. The soil of this area is apparently as good as that farther south, but it is very dry in dry weather, and there is no marked humus covering. Perhaps the proximity to the well drained valley on either hand has an influence through underground drainage, but this was not looked into, and the question must be left for the present unanswered.

Within the sand plain area of the southern half of the county there are several small stretches of societies I and II. Owing to the fact that at one time a much larger stream than the present one flowed through the valley of the Thornapple River, that valley has a well marked terrace between the country level and the present flood plain. This old flood plain is sandy and corresponds in manner of formation to the Grand Rapids sand plain. But in very many places this terrace is covered with societies I or II. Some of the finest "sugar bushes" to be seen in the county are here. The sandy soil is thickly covered with a layer of humus. These strips of hardwood are so narrow that they could not well be shown upon the map The same condition holds on the rather high part of the plain lying west of Crosby. This is indicated upon the map. Also at the base of the escarpment forming the margin of the deeper glacial channel in the Grand Rapids sand plain, there are several instances of societies I and II upon humus-covered sand. Notably is this true near the southwest corner of Grand Rapids and on the margin of the Buck Creek valley near the Lake Shore and Michigan Southern railroad. In this connection it is interesting to note that beech trees are found quite commonly upon the humus-covered established dunes along the east shore of Lake Michigan.[9]

[9] Dr. Cowles tells me that he has seen these beech covered dunes as far north as Frankfort, and Mr. Whitford has observed them on Manitou Island.

In the northern half of the county, west of the Rouge River, we find the heavier soils still retaining societies I, II, and III. East of the valley of this river we find the country is much cut up. The clay areas are small and rather well drained. They may be occupied by any society from I to V. That they can support society I is well shown by its occurrence in several places. Its general absence from this region is perhaps due to another cause, to be mentioned later.

East of Sparta and northeast of Cedar Springs are perfectly typical examples of society I growing upon light soil, the former without trace of pine. In the western part of the Sheffield area I was told by a resident that the clay was at least twenty feet below the surface. But in these areas the soil is deeply covered with humus. What the conditions are which cause the accumulation of humus in one place and not in another apparently similar place, I was unable to make out. This accumulation most often occurs in rather low regions, where the sand would normally remain moist longer than elsewhere. The maple-elm-agrimony society grows to perfection on heavy soil with little or no true humus. It is also found on lighter soil which has a humus covering.

In the southern half of the county it seems fairly clear, then, that societies I and II will grow on rather deep sand if that be covered wiih humus, and that when society V is found on clay it is well drained and usually with little or no humus. Throughout the county there is an obvious difference in humus content between the areas occupied by societies IV and V, the sand of the former being mixed with vegetable débris The intermediate society III is found on the loamy soils and on the dryer and better drained clay areas.

b. *The historic factor.*—Besides the factor of relative water content in the soils there is another which may be active in this region, namely, what may be termed the historic factor. As the ice sheet retreated slowly northward at the end of the last glacial period, the portions of Kent county first uncovered were of course in the southern part. And the first parts of the sand plains to be uncovered lay also at the south, although these areas

were probably under water long after the ice itself had disappeared. It is probable that the pine-heath[10] group, which today reaches farthest north, reached well toward the glacier front during the ice age. And at the end of that age, the ice in its retreat was probably followed northward by vegetation, the pine-heath society leading the way. Near the ice margin the soils were probably raw, absolutely without humus, subject to great drought in summer and to extreme cold in winter. These are just the conditions in which the pine-heath group is found today in northern Michigan. It is probable that at one time they occupied all of Kent county, but the climate became warmer and more equable with the farther retreat of the ice, and the growth of the hardy pines, etc., produced a little humus. Their roots fixed the soil so that erosion was less rapid and perhaps the sassafras and the white and red oaks and the whole of our society V gradually crept in, occupying the better part of the ground along with the pines and heaths. Then, as the soil improved, the oaks became more and more numerous, and the pine seedlings could not develop on account of the shade. The pines thus became fewer in the south and the oaks at last predominant. This would be the stage of society IV. But the process of working over the soil continued, though perhaps the ice-sheet had shrunken by this time nearly to its present size, and humus continued to accumulate in favored places; the hickories, maples, and beeches of Ohio and Indiana spread continually northward over every suitable stretch of soil, as fast as it was made fit for them. When the maples and beeches reached maturity in the richest parts of the oak and hickory forest, the oaks and hickories probably ceased to mature. Seedlings of these trees fail to develop well under maples and beeches, possibly on account of the dense shade. Thus the stage of society I might be reached.

In such a northward advance, the plant societies would not progress in uniform lines. On the contrary, there would be many mixed areas, and the advance would often be almost

[10] This group comprises, besides several pines, two species of juniper, bearberry, hairbell, bracken, and several of the other forms found in our society V. Cf. WHITFORD, H. N. The genetic development of the forests of northern Michigan; a study in physiographic ecology. BOT. GAZ. 31: 289–325. 1901.

imperceptible. Here and there in a sterile, perhaps in a well drained, portion, would be left a detachment of the advance guard, like the patches of societies V and IV in the southern townships of the county. And these would be surrounded and left as relics by the later comers as they advanced, occupying all soils in which they could come to maturity, and preventing the development of new generations of the forms previously in possession. With these thoughts in mind, a glance at the map will suggest much more than was suggested before.

The beech and maple societies (considered by Cowles and Whitford[11] to be the climax society for temperate North America) extend northward along the lines of soil richest in water content, and reach farthest north in the western part of the county. This latter fact may be due to the lake influence. Chamberlin states[12] that in Wisconsin the beech is limited to regions near the lake. He believes its distribution to be determined by lacustrian climate. This is very doubtful, however. Also the other societies—II, III, and IV—are each a little in advance of the previous one, and each is apparently advancing into the area occupied by the next hardier one. In the extreme north we find almost the entire area occupied by societies IV and V.

According to this line of thought, the reason for the predominance of the pine groups in the northern part of the county is that sufficient time has not yet elapsed since the glacial period for these areas to be reached by the societies found predominant farther south. Along a wavy east and west line passing through Rockford lies the "zone of tension" between societies I, II, and III on the one hand, and IV and V on the other. This line bends far northward at the west, following the western edge of the Rouge valley as far as Kent City and Casnovia. It also bends northward to Sheffield and Harvard on the other side of the Rouge valley. It may be that the climate, somewhat colder as we pass northward, has acted as a retarding factor,

[11] WHITFORD, H. N., *loc. cit.*, p. 302.

[12] CHAMBERLIN, T. C., Native vegetation of Wisconsin. Geol. of E. Wisconsin 2:176. 1873–1877.

assisted by the fact that a good portion of these northern townships have a light surface soil, which seems unsuited for the hard wood societies in the absence of humus. That the climatic factor is not the main one in this is shown by the existence of vast reaches of typical maple and beech forest in the northern part of the peninsula.

The strongest point in favor of the idea just expressed is found in the fact that at the time of settlement practically all of societies I and II in the northern part of the county were well mixed with pine. In some places the pine stumps are so numerous as to raise the question whether the hardwood is not an entirely recent development. It is probable, however, that scattered maples and beeches were mingled with the pine, and that on the removal of the latter their seedlings simply took possession of the ground and shut out the pine seedlings.[13] Also in societies II and III, west of Rockford and as far south as Mill Creek, the pine is still pronounced, and in many small spots society IV, or even V, still retains its hold. As has been noted before, this is a mixed group and is hard to classify. There are no traces of pine in the hard wood forests to the southward. It may well be, however, that a further extension of this study will show that this hypothesis of the historic factor is utterly untenable.

Another line of evidence seeming to throw some light upon the historical development of this flora is that obtained from a comparison of the several sand plains of the region. There is a well marked sand plain just south of the boundary of Kent county, which I have termed the Green Lake sand plain. The soil here is like that of the higher part of the Grand Rapids plain, very sandy, but with a good admixture and coating of humus so that at the surface it appears loamy. The vegetation is made up of all five of our societies. In general the type is that of society III, but there are many spots, especially on the

[13] Beal has shown that oaks, maples, etc., can reach a considerable age in dense forests without any marked growth. An oak may thus be twenty-five years old and yet have a height of only a few inches. If the shade-producing plants are removed these dwarfed trees will set up a renewed growth. For figures of such dwarfed trees see BEAL, W. J., Observations on the succession of plants in northern Michigan. Annual Report Mich. State Board of Agriculture **27**: 74–78. 1888.

margins of the numerous ponds and lakes where societies IV and V hold the ground. In slight depressions along the margin of the plain the humus is deep and society I is common. There are also many rather large areas of societies I and III well out in the plain. Usually these are in slight depressions, not low enough to be swampy, but well covered with humus. We may say, then, that in the most southern of the three sand plains which have been studied, and therefore the one which has been out of water and fit for vegetation the longest, the predominant society is III; but I and II are not uncommon; while IV and V occupy a relatively small portion of the area.

In the Grand Rapids sand plain, society IV is predominant, with a good part occupied by V and comparatively very little by I, II, and III. And in the plain which extends from Rockford northward, the only upland society found is V. Of course the last plain has been out of the water a much shorter time than the other two. In fact, a great part of it is at present swamp and is occupied by lowland societies.

In these three plains, perhaps, are seen successive stages of vegetation occupying successive stages in the formation and accumulation of humus. Of course the extensive destruction of the natural vegetation which has taken place since settlement of this region began will make it impossible for the natural course of events to continue here, even if the above hypothesis be the correct one. Clearing and burning have often reduced the soil from a condition suited to society II or III to one only fit for society V. This is probably also true on the moraines in the northern part of the county. It will probably be impossible ever to trace the history much farther than it had gone at the time of settlement.

CONCLUSIONS.

The present observations appear to justify the retention, as a broad general hypothesis, of the physiographic idea advanced by Cowles, namely, that physiography determines vegetation. But this hypothesis does not come close enough to the ultimate factor upon which depends the distribution of the plant

societies. The ultimate cause of all this varied vegetation must be something more particular, something which will affect the individual plant. For such a region as this, this *something* must exist in the nature of the soil; climatic factors cannot explain differences in such a small area; and the historical factor is broad and general, like the physiographic one, and hence is not ultimate. That local differences in vegetation are due to soil factors has been practically proved before this, and the proof is strengthened by the present study. The physiographic hypothesis explains how it is that various soils may be physically and chemically different. But, after this is explained, the question with which we have to deal lies still untouched: *What is it in the nature of the soil which determines the distribution of our plant societies?*

Now, by "nature of the soil" two things may be denoted, and only two, *i. e.*, the *physical* nature and the *chemical* nature. But neither of these can influence the plant *per se*. Either one of the features may be effective, however, through soil water. Water is the only feature of the soil which comes in direct connection with the vitality of the plant. The chemical nature of the soil may be directly effective through the nature of the dissolved substances which enter the plant, or indirectly, through osmotic pressure. Its physical nature may be effective through the retention or non-retention in the soil of the water itself.

So far we may go *a priori;* beyond this, tests must be made. The nature of the soil water from various soils in various positions must be carefully determined. From these determinations will be shown how much truth or falsity there is in the explanation here offered, that the nature of the soil water is not usually a decisive factor for such a region as this.

Also, by careful tests the ability of various soils to retain water must be determined, and these determinations recorded with the vegetation found growing where the tests were made. Thus, and thus only, can the hypothesis here offered be tested, *i. e.*, the hypothesis that *the decisive factor in plant distribution over a small glaciated area is, in most cases, the moisture-retaining power*

of the soil.[14] Mere field observations can neither destroy this hypothesis nor establish it.

On the other hand, the present series of observations seems to show that the historic factor may be a very important one in the distribution of the plant societies of Kent county, and the test of the hypothesis offered in this connection is to be obtained through observation and comparison, and through them alone.

It is hoped that in the future studies may be made of other areas lying north and south of this one, and the results carefully mapped and published. Emphasis is here laid on the map, for by it alone can a satisfactory comparison be instituted. Photographs are apt to be too superficial to be of any accurate use, though they would undoubtedly be valuable in connection with the map.

HULL BOTANICAL LABORATORY,
THE UNIVERSITY OF CHICAGO.

[14] Similar conclusions to the one here expressed have been published by Mr. Bruncken. BRUNCKEN, E., Studies in plant distribution. 1. On the succession of forest types in the vicinity of Milwaukee. Bull. Wis. Nat. Hist. Society **2**: 17–28 1902.

BRIEFER ARTICLES

CONTRIBUTIONS TO THE BIOLOGY OF RHIZOBIA.

II. The motility of *Rhizobium mutabile*.

In previous communications[1] I stated that *Rhizobium mutabile* was absolutely non-motile. Further investigations have proved this to be incorrect. The former conclusion was based upon the observation of organisms grown in and upon neutral culture media. In neutral or very slightly alkaline solid beef gelatine or beef agar there is absolutely no active motion on the part of the organisms, whether cultures are recent or old. Nor do the organisms undergo any great change in size or form. As soon as the Rhizobia of sweet clover are transferred to acid media they undergo great changes in size and form. They are much smaller and more uniform in size. Branching forms are very rare, and the sporoids or highly refractive peripheral bodies are few and indistinct, but the cytoplasm is quite unequally distributed, as shown in the stained organisms. As a rule the cytoplasm is collected at either end, also at the middle, giving in the stained material the semblance of spores.

The motion is quite characteristic. It is a rapid, jerky, to-and-fro, and rotary motion and continues during the period of active septation, so that two or three incompletely divided organisms are seen moving about in the liquid media. If the medium is very slightly acid, only a few organisms show motility; or more correctly speaking, perhaps, in such media motion exists for a brief period only. In media which are quite acid most of the organisms show motion. In fact, the number of motile forms is proportionate to the degree of acidity. When motile forms are transferred to neutral or slightly alkaline solid media they develop into large, branching and non-branching, non-motile forms. Early in the experiments the presence of motile forms in what were supposed to be pure cultures of Rhizobia of sweet clover led me to believe I had to deal with contaminations with foreign bacteria. In fact, whole series of cultures were rejected as a consequence of this

[1] Beitrag zur Kenntnis der Rhizobien: Ber. Deutsch. Bot. Gesell. **12**: 11–17. 1894. Contributions to the biology of Rhizobia, I. Rhizobium mutabile in artificial culture media. Bot. Gaz. **34**: 109–113. 1902.

erroneous belief. The fact, however, that these cultures retained the general macroscopic characters of those which showed no motile forms led me to believe that they were, after all, not contaminations, but simply the product of a change in media, a conclusion fully verified by subsequent tests and experiments with media varying in degree of acidity. The discovery is also in harmony with recent observations of Arther Meyer,[2] and has further very important bearings upon my former conception of species of Rhizobia.[3] Rhizobia which I formerly described as *R. Frankii*, *R. Frankii minus*, and *R. Frankii majus* are in all probability merely motile forms of *R. mutabile*. But, as yet, the question of species and varieties of Rhizobia is far from settled. The more recent investigations point toward the existence of well-established varieties of one or at most a few species, of which *R. mutabile*[4] will unquestionably prove to be the chief or dominant type, as it occurs in the root tubercles of the greater number of leguminous plants.

R. mutabile cultures in acid solid media have a grayish tinge from the very first, which color becomes lighter, finally changing to brownish gray, and the cultures become less liquid and tenacious; otherwise they are as in neutral solid media. Rhizobia also tend toward motility in liquid neutral media. Observations lead to the conclusion that motility is the result of unfavorable conditions as to food supply, on the one hand, and an increased plasticity resulting from an abundance of liquid environment. Motility thus enables these organisms to compete more successfully in the struggle for existence. The motile forms are, in all probability, the normal, more highly specialized organisms, while the larger, branching, more polymorphous forms are degenerate types, adapted to a fixed and abundant food supply of the host plant. At least this seems to be a justifiable theoretical conclusion from the purely structural or anatomical point of view. Further experimentation is necessary to determine whether the motile forms are functionally more highly specialized, and whether these have a greater free nitrogen assimilating power or function.

The following is a summary of the experiments:

1. *Rhizobium mutabile* is non-motile in most neutral media, especially in solid neutral media.

[2] Kurze Mittheilung über die Begeisselung der Bakterien. Centralbl. f. Bact. u. Parasit. **31**: 15. 1902.

[3] Observations on some American Rhizobia. Bull. Torr. Bot. Club **19**: 203–218. 1902.

[4] The *R. Leguminosarum* of Frank.

2. It is decidedly motile in acid media, whether these media are liquid or solid.

3. In acid media the growths become grayish to light gray and brownish gray in color.

4. Motile Rhizobia are much smaller and more uniform in size and form.— ALBERT SCHNEIDER, *Northwestern University, Chicago.*

CURRENT LITERATURE.

BOOK REVIEWS.

Books on trees.

THERE HAS LONG BEEN a demand for a nature-study book on trees that would contain something more than mere systematic studies. This demand Julia Ellen Rogers[1] has met in an admirable manner. This work is divided into four parts. In the first part (pp. 1–42), under the heading "outdoor studies with trees," the author writes in a very entertaining way on the life-history of the maple, how to tell the age of a tree, the battle among the twigs, thorns, and prickles, and other subjects. The second part (pp. 43–65) deals with the physiology of trees. The respiratory and photosynthetic processes are described simply and accurately; but under the heading "the sleep of trees" there are many unscientific and misleading statements. The heading itself illustrates this point. When we say that trees sleep we are getting out of the realm of facts into fancy. It is a question, of course, how far "fancy" can be carried into nature-study books. The line should be drawn so sharply that wrong inferences will not be made. The following sentence illustrates the point, and there are many more like it: "If the sky is overcast, the tree is drowsy; if rain sets in, it goes right off to sleep." We suppose that this is a reference to the photosynthetic process, but to the uninitiated this would convey the idea that the tree is actually drowsy in the same sense that animals are. A third section of the book (pp. 65–119) treats of the cultivation of trees. In a very clear and fascinating way the principles of landscape gardening are discussed, and one is told how to plant and trim trees. The forestry question, the farmer's wood lot, fruit trees, nursery trees, and diseases of trees — all subjects seldom mentioned in nature-study work — add materially to the value of the book. In the fourth part about 125 different kinds of trees are described. Too much cannot be said in praise of the workmanship of the book. The twenty-five full-page photogravures of entire trees and many half-tones of trunks and leaves are identical with those formerly issued by the publishers in the portfolio known as Series I, II, and III of *Typical forest trees*. While it might detract from the beauty of the book to number the illustrations, it would add much to its usefulness. *Among green trees* should be in the hands of all teachers of nature.

[1] ROGERS, JULIA ELLEN, Among green trees. A guide to pleasant and profitable acquaintance with familiar trees. 8vo. pp. xxii + 202. *pls.* 25. *figs.* 155. Chicago: A. W. Mumford. 1902.

TWO RECENT BOOKS on forestry[2] will help greatly to popularize the knowledge of this subject, and too much cannot be said concerning their usefulness. The science of forestry has made such rapid progress during the last ten years that any work that discusses in a readable yet scientific way the subject in all its phases should find a ready sale among teachers of nature-study, woodland owners, beginners in forestry, and others. Both works have features in common, yet in a way they supplement each other.

ROTH presents the subject in the simplest possible manner. The relation of the forests to light, shade, soil, moisture, and temperature is discussed. The subject of "forestry" is treated under the following headings: the raising and keeping up the forest, its care, its use, and its business. A third part deals with the forest as a protective cover, the distribution of the forests in the United States, the wood and its properties, and closes with a valuable key to the common trees of the United States.

GIFFORD in the first part discusses the meaning of "forest" and "forestry," and treats of wood lots on farms, the forest canopy, the forest as a soil improver, the geographical distribution of forests, and barriers to forest extension. Part II treats of the formation and tending of forests. The author recognizes the intimate relations existing between the study of forestry and forest botany, especially plant ecology. In the third part the industrial phase of the subject is treated in a very interesting way, and in Part IV are brief descriptions of the location, areas, and special features of the forest reserves. Both books are well illustrated, mostly with half-tone reproductions of photographs.—H. N. WHITFORD.

Books for schools of pharmacy.

DR. ALBERT SCHNEIDER'S recent book[3] dealing with powdered vegetable drugs is the only work of its kind in English. In it 195 vegetable powders are described, 164 of them being figured. The first part treats of the color, odor, and test of vegetable drugs, the general histology of vegetable powders, equipment and methods of examination, parasites, adulteration, powdering and sifting, and includes two keys for identification. The second part contains a special description, with illustrations of the more important vegetable powders used in the United States.

DR. HENRY KRAEMER has prepared a book[4] intended to meet the botanical needs of students of pharmacy. The first part deals with plant

[2] GIFFORD, JOHN, Practical forestry, 8vo. pp. xiv + 284. *figs. 35*. New York: D. Appleton & Co. 1902.

ROTH, FILIBERT, First book of forestry. 8vo. pp. ix + 281. *figs. 98*. Boston: Ginn & Co. 1902. 85c.

[3] SCHNEIDER, ALBERT, Powdered vegetable drugs. 8vo. pp. 323. Pittsburg: Calumet Publishing Co. 1902. $2.50.

[4] KRAEMER, HENRY, A course in botany and pharmacognosy. 8vo. pp. 384. Philadelphia: The author. 1902.

morphology, under the two general headings of "the cell" and "the vegetative and reproductive parts of the plant." The treatment of these subjects is not from the modern biological standpoint, but rather from the standpoint of the details and terminology used by pharmacists. The second part treats of pharmacognosy, the two chapters being entitled "crude vegetable drugs" and "powdered vegetable drugs." The third part deals with reagents, and the fourth part consists of a set of seventeen plates.— J. M. C.

MINOR NOTICES.

A BULLETIN[5] of considerable economic importance has just been issued by the Bureau of Forestry. The work is divided into two parts. In the first part Hall describes several successful plantations in Kansas and discusses the important cultural points. In the second von Schrenk treats of the fungus diseases. The mycelium of *Polyporous versicolor* frequently destroys the heart wood of the tree. The bulletin is excellently illustrated.—H. N. WHITFORD.

E. S. BURGESS[6] has published a first volume of Aster studies, which is confined to the general historical treatment, leaving the description of species to a volume soon to follow. "The present volume traces the history of Aster to 1600, or through the continuance of the ancient monotype conception of Aster; that is, until Clusius's polytype conception came into full dominance as embodied in the series of Aster species set forth by him in 1601." The volume is really a sketch of the history of pre-Clusian botany, and is a very welcome addition to the botanical literature of English readers.—J. M. C.

A NEW FASCICLE[7] of Urban's *Symbolae Antillanae* has appeared. The first paper (pp. 161–274) is a presentation of Piperaceae by C. DECANDOLLE, 152 species being recognized, 27 (Piper 21, Peperomia 6) of which are described as new. The second paper (275–279) is a continuation of the description of new Hepaticae (10 in number) by F. STEPHANI. The third paper is a continuation of descriptions of new genera and species, by I. URBAN. The new species are 56 in number, and the new genera are *Chaenotheca* (Euphorbiaceae), *Krugiodendron* (Rhamnaceae), and *Neobuchia* (Bombacaceae).— J. M. C.

MILLSPAUGH[8] has published an account of the flora of St. Croix, the largest of the group of islands known as the Danish West Indies. A general

[5] HALL, W. L., and VON SCHRENK, HERMANN, The hardy catalpa. Bureau Forestry, U. S. Dept. Agric. Bull. 37. pp. 58. *pls. 30.* 1902.

[6] BURGESS, E. S., History of pre-Clusian botany in its relation to Aster. Mem. Torr. Bot. Club 10: 1–447. 1902.

[7] URBAN, IGNATIUS, Symbolae Antillanae seu fundamenta florae Indiae occidentalis. Vol. III. fasc. II. pp. 101–352. Leipzig: Gebrüder Borntträger. 1902. *M.* 10.80.

[8] MILLSPAUGH, C. F., Flora of the island of St. Croix. Field Columb. Mus. Publ. 68. Bot. Series 1: 441–546. with map. 1902.

account of the general ecological features and plant products of the island is followed by an interesting "Botanical history," which gives a very full account of botanical work on the island previous to the visit by the author himself. The list is based on Baron Eggers's well-known Flora of St. Croix and the Virgin Islands, 117 species being added. The total flora, as now known, numbers 1,029 species, 992 of which are vascular plants. It is pleasant to note that the author has succeeded in distributing his whole collection under published species, with the single exception of a species of Cordia.—J. M. C.

THE FIRST PART of Sargent's *Trees and Shrubs*[9] has appeared. The general scope of the work may be obtained from the title and from the preliminary announcement made in BOT. GAZ. 34: 388. 1902. Those acquainted with the *Silva* of Professor Sargent will recognize the same general style and arrangement of text and plates, the latter being reproductions of original drawings made by C. E. Faxon, probably the most skilful and experienced botanical draftsman in America. This first part contains descriptions and illustrations of *Juglans mexicana* S. Wats., seven new species of Crataegus (*C. durobrivensis* Sarg., *C. Laneyi* Sarg., *C. Coleae* Sarg., *C. maloides* Sarg., *C. luculenta* Sarg., *C. fruticosa* Sarg., *C. paludosa* Sarg.), *Eupatorium Loesenerii* Robinson, *Senecio Robinsonianus* Greenm., *Styrax Ramirezii* Greenm., *Faxonanthus Pringlei* Greenm. (a new Mexican genus, singularly described with no statement as to its family), *Ehretia viscosa* Fernald, *Berberis Sieboldi* Miq., *Ilex serrata* Thumb., *Acer capillipes* Maxim., *A. Tschonoskii* Maxim., *Malus Halliana* Koehne, *Viburnum Wrightii* Miq., four new species of Lonicera (*L. saccata* Rehd., *L. Koehneana* Rehd., *L. ferruginea* Rehd., *L. arizonica* Rehd.), *L. Griffithii* Hook. f. and Thoms., *Enkianthus subsessilis* Makino.—J. M. C.

NOTES FOR STUDENTS.

MASSART has published a preliminary work[10] on the influence of pollination on the growth of the fruit of Cucurbitaceae. He finds that the initial stimulus to growth is from the pollen, and is perceptible when killed pollen is applied to the stigma. The further growth of the fruit is dependent on a stimulus from the "fertilized ovules," whose transmission is limited, so that cavities are formed when no embryos are formed in some chambers of the fruit.— E.B. COPELAND.

[9] SARGENT, CHARLES SPRAGUE, Trees and shrubs, illustrations of new or little known ligneous plants prepared chiefly from material at the Arnold Arboretum of Harvard University. Part I. Boston and New York: Houghton, Mifflin & Co. 1902. $5. net.

[10] MASSART, I., Sur la pollination sous fécondation. Bull. Jard. Bot. État. Bruxelles 1: fasc. 3. pp. 7. 1902.

FREDERIC E. CLEMENTS has published[11] a paper entitled "Greek and Latin in biological nomenclature." Its purpose may be expressed in the following quotation: "The following treatise is intended to serve as a compendium of the principles of word-formation in Greek and Latin of sufficient thoroughness to enable the biologist to construct in proper manner any derivative desired. Further than this, various unfortunate usages which have obtained in nomenclature and the many types of malformations will be considered in detail, and suggestions will be made for their correction or elimination."—J. M. C.

FERRARIS[12] has undertaken a morphological study of the Iridaceae, his first paper dealing with Romulea. The archesporial cell gives rise to a row of three megaspores, the innermost of which functions. The synergids show a prominent development of the filiform apparatus. The three antipodals become very large and send out beaks into the projection of chalazal tissue that extends into the antipodal extremity of the sac. The sac finally completely replaces the nucellus, the extremity being freely exposed in the micropyle. The remaining phenomena recorded are those common among monocotyledons.—J. M. C.

IN HIS STUDY of the parasitism of *Buckleya Quadriala*, Kusano[13] reaches the following conclusions: The haustorium is provided with a cambium ring between its cortical and axial parts which joins that of both the host and the mother-root; the form and structure of the haustorium change with age; it possesses medullary rays, but the existence of sieve tubes could not be determined definitely; the sucker, easily distinguishable in the younger stage, loses its distinctiveness from the part behind after a certain amount of growth; as long as the host root is alive the haustorium may be active and can maintain its life during many years.—J. M. C.

A PAPER by Neubert[14] on the nutations of the cotyledon of Allium comes to these conclusions: (1) the formation of the characteristic knee is automatic, though influenced by negative geotropism and the consistency of the earth; (2) the elimination of the curve is also chiefly automatic, but here too gravity has some directive influence; (3) the formation of the protuberance on the knee is dependent on darkness and friction. Neubert seems not to know of the existence of my work on the geotropism of these cotyledons,[15] nor of

[11] University Studies, Univ. Nebr. **3**: 1–86. 1902.

[12] FERRARIS, TEODORO, Ricerche embriologiche sulle Iridacee. I. Embriologia del G. *Romulea* Maratti. Ann. R. Istit. Bot. Roma **9**: 221–241. *pls. 6–7.* 1902.

[13] KUSANO, S., Studies on the parisitism of *Buckleya Quadriala* B. et H., a santalaceous parasite, and on the structure of its haustorium. Jour. Coll. Sci. Imp. Univ. Tokyo **17**: article 10, pp. 42. *pl. 1.* 1902.

[14] NEUBERT, R., Untersuchungen über die Nutationskrümmungen des Keimblattes von Allium. Jahrb. Wiss. Bot. **38**: 119–145. 1902.

[15] COPELAND, E. B., Positive geotropism in the hypocotyl or cotyledon. BOT. GAZ. **31**: 410–421. 1901.

Noll's fine work on Cucurbita,[16] which in essentials antedates about all that might otherwise be novel or valuable in this paper from the Leipzig laboratory.—E. B. COPELAND.

HARTLEY,[17] in studying the effects of premature pollination in tobacco, cotton, and tomato, has reached the following definite conclusions: "that the application of good tobacco pollen to immature tobacco pistils causes the flowers so treated to fall from the plant because of the growth of pollen tubes into their ovaries; that tobacco and tomato plants sometimes set and ripen fruits without the flowers having received any pollen, and that such fruits contain no germinative seeds; and that but few fruits will be obtained by the pollination of immature cotton and tomato pistils, but that good percentages may be obtained if the pollination is performed when the pistils are receptive."—J. M. C.

IN A SHORT PAPER on the controlling factors in the direction of branch growth, Wiesner[18] suggests that the position of lateral branches may be a resultant due to the action of negative geotropism on the one hand and to epinasty on the other. As the intensity of epinasty varies with age in some forms, changes in direction which occur as a branch matures may often be explained on this ground, the intensity of negative geotropism being constant as long as growth continues. Since practically nothing is known as to the true nature of epinasty, and since quantitative measurement of geotropic reaction is at least very difficult, it seems to us that such conclusions as the above can be of little avail in advancing true physiology.—BURTON E. LIVINGSTON.

WEISS[19] has elucidated in an interesting way the structure of the tracheary branches first described by Renault as occurring in stigmarian rootlets. He shows that these tracheary strands occur in typical monarchous rootlets. They run from the protoxylem group across the generally lacunar middle cortex of the root and end in a special organ composed of large tracheary elements in the outer cortex. On account of the absence of dichotomy, he draws the conclusion that they cannot be strands belonging to branch-rootlets, but rather represent special water-absorbing organs rendered necessary on account of the usually almost complete separation of the central cylinder of the stigmarian rootlet from the outer cortex.—E. C. JEFFREY.

[16] NOLL, F., Zur Keimungsphysiologie der Cucurbitaceen. Landw. Jahrb. Ergänzungsband I. 1901.

[17] HARTLEY, CHARLES P., Injurious effects of premature pollination. Bull. 22. Bureau of Plant Industry, U. S. Department of Agriculture. Oct. 4. 1902.

[18] WIESNER, J., Regulirung der Zweigrichtung durch "variable Epinastie." Ber. Deutsch. Bot. Gesell. **20**: 321–327. 1902.

[19] WEISS, F. E., The vascular branches of stigmarian rootlets. Ann. Botany **16**: 559–574. *pl. 26.* 1902.

KRAEMER,[20] in his study of the structure of the starch grain and the cell-wall, has discovered that certain appearances described by various authors as indicating a continuity of protoplasm are due to a peculiarity in the structure of the cell-wall, which is made manifest by the reagents employed, and which resembles the structure of the starch grain. He also calls attention to the fact that investigators have generally fallen into the error of supposing that a certain aniline dye could be regarded as a differential stain for protoplasm, whereas the fact is that many colloidal carbohydrates, as mucilage and pectin, and oils and other substances as well, take up these stains. If the substance in the cell-wall which takes up the stain is protoplasm, what is it in the starch grain ?—J. M. C.

STORER[21] adds very materially to our knowledge of mannan as a stored food-stuff in plants by a series of notes on the detection of its hydrolysis product, mannose. A long experience in the study of these substances gives him the right to speak authoritatively on the methods best adapted to their identification and estimation. The methods are clearly described and the difficulties fully discussed. He finds abundance of mannan in the following plant tissues: date stones, ivory nut, flesh of ripe cocoanut, seeds of *Trifolium repens*, and the wood of *Pinus Strobus*, *P. rigida*, *Picea excelsa*, *Larix leptolepis*, *Tsuga canadensis*, *Juniperus virginiana*, and *Chamaecyparis sphaeroidea*. Smaller amounts of mannan are contained in a number of other tissues tested.—BURTON E. LIVINGSTON.

UNDERWOOD[22] has given a surprising account of the genus Gymnogramme as presented in Hooker's *Synopsis Filicum*. So far from being a natural assemblage, it contains among its species a number of generic groups, several of which bear no close phylogenetic relations to the others or to each other, some even belonging to different tribes. Some of these genera submerged under Gymnogramme are related to the Polypodieae, others to the Aspidieae, one possibly to the Vittarieae, but more are distinctly related to the Asplenieae. The name Gymnogramme being a typonym of the monotypic Gymnopteris, established thirteen years earlier, disappears from botanical nomenclature. The two species occurring within the limits of the United States heretofore referred to Gymnogramme represent two distinct genera, *Ceropteris* Link and *Bommeria* Fourn.—J. M. C.

MENDEL[23] has investigated the products formed by the action of papain, the proteolytic enzyme of the fruit of *Carica papaya*, upon proteids, with the

[20] KRAEMER, HENRY, On the continuity of protoplasm. Proc. Amer. Phil. Soc. **41**: 174–180. *pls. 21–22.* 1902.

[21] STORER, F. H., Testing for mannose. Bull. Bussey Inst. **3**: 13–45. 1902.

[22] UNDERWOOD, L. M., American ferns. IV. The genus Gymnogramme of the Synopsis Filicum. Bull. Tor. Bot. Club **29**: 617–634. 1902.

[23] MENDEL, L. B., Observations on vegetable proteolytic enzymes, with special reference to papain. Am. Jour. Med. Sci. pp. 9. (Aug.) 1902.

following results: Papain is active in both acid and alkaline media, forming caseoses and casein peptones which closely resemble these bodies as they are produced in gastric digestion. Thus this enzyme is like pepsin as to the products of its action, but unlike it in that pepsin cannot act in an alkaline medium. Trypsin, as is well known, develops its action in an alkaline medium as well as in an acid one, but its products are quite different from those of pepsin, being mainly leucin, tyrosin, and tryptophan, none of which were found among the products of papain digestion. Mendel concludes, therefore, that papain must be regarded as belonging to a class quite distinct from that of either pepsin or trypsin.— BURTON E. LIVINGSTON.

PALLADIN[24] has added to his former researches concerning the generation of chlorophyll in etiolated leaves. He had already shown that such leaves, when cut and exposed to sunlight, fail to become green unless they contain carbohydrate material or are supplied with it from a solution into which they dip.[25] Moreover, not only can solutions of saccharose and glucose bring about this effect, but other carbohydrates are also available, *e. g.*, raffinose, fructose, maltose, and even glycerin.[26] In the present study he has been able to show that the formation of chlorophyll in such leaves depends upon the concentration of the solution, which may be either too weak or too strong to produce the response. The optimum greening is in a medium concentration. That strong solutions of saccharose can inhibit greening is explained by the fact that they greatly retard oxidation; the process of chlorophyll formation is known to b, at least in part, one of oxidation.— BURTON E. LIVINGSTON.

IN THE FOURTH of his studies on the genus Selaginella, Harvey-Gibson[27] discusses the anatomy and development of the root. He concludes that the so-called rhizophores which are characteristic of certain species of Selaginella do not possess the morphological value of caulomes, but are merely the aerial portions of roots. He points out their close relation to branches, a correlation which, by the way, presents a striking parallel to the condition found in Equisetum and the other Lycopsida. The author suggests that, in those cases where a leafy branch grows out from the situs of a rhizophore, there is really present a branch-root combination in which the root has been suppressed. The internal structure of the typical root and the rhizophore is the same, both being monarchous and possessing a well-marked endodermis. The xylem of the root is generally perixylic, but in the rhizophoric portions

[24] PALLADIN, W., Einfluss der concentration der Lösungen auf die Chlorophyllbildung in etiolirten Blättern. Ber. Deutsch. Bot. Gesell. **20**: 224–228. 1902.

[25] PALLADIN, W., Ergrünen und Wachsthum der Etiolirten Blätter. Ber. Deutsch. Bot. Gesell. **9**: 429. 1891.

[26] PALLADIN, W., Recherches sur la formation de la chlorophylle dans des plantes. Rev. Gén. Bot. **9**: 385. 1891.

[27] HARVEY-GIBSON, R. J., Contributions towards a knowledge of the anatomy of the genus Selaginella. Ann. Botany **16**: 449–466. *pls. 20–21.* 1902.

of the root in *S. Krausiana*, *S. delicatissima*, and *S. Poulteri*, it is centroxylic.— E. C. JEFFREY.

TREUB[28] has concluded that *Ficus hirta* produces parthenogenetic embryos, and that this may be true of all the species of Ficus. Although pollen grains on the stigma were observed to put out tubes, no tubes could be found penetrating toward the sac or within the sac; and yet there was an abundance of developing embryos, from the undivided egg to a many-celled stage. Treub supports this argument for parthenogenesis by the feeble development of endosperm, and the poorly organized egg apparatus, especially the synergids; but neither point seems to be well taken. In fact, the evidence of parthenogenesis in this case is the repeated failure to find any trace of pollen tubes where they ought to be in case fertilization occurs The suggestion is made that the stimulus to segmentation in this case is the puncture of the pollinating Blastophaga. Since there are only three recorded cases of parthenogenesis among angiosperms, there is no reason why the author should mention Juel's Antennaria and Murbeck's Alchemilla and omit Overton's Thalictrum.— J. M. C.

SHOEMAKER[29] has obtained some interesting results from a study of *Hamamelis virginiana*. In each anther two sporangia appear instead of the usual four, and dehiscence is by means of a door-like valve hinged on the side towards the carpel. The pollen grains show great resistance to low temperature; some were observed to send out tubes after a week of cold weather during which the temperature was at times as low as −15°. Perhaps the most interesting fact is the long period between pollination and fertilization, putting Hamamelis in a category with the Amentiferae in this regard. Pollination occurs from October to December; and the tubes at once enter the nucellus and grow rapidly until cold weather. Live tubes were found in January and February safely embedded in the hairy part of the carpel. In the spring growth is resumed and fertilization occurs about the middle of May, five to seven months after pollination. The endosperm nucleus begins to divide after fertilization, and walls begin to appear at about the 12-nucleate stage, the walls appearing first at the bottom of the sac.— J. M. C.

MASSART[30] has issued reprints of three papers on irritability. The first and longest deals with positions of equilibrium toward stimuli acting alone or together. Massart assumes an actual or possible transmission of a stimulus in many cases where it has yet to be demonstrated; the same experiments as

[28] TREUB, M., L'organe femelle at l'embryogénèse dans le *Ficus hirta* Vahl. Ann. Jard. Bot. Buitenzorg II. 3:124–157. *pls. 16-25*. 1902.

[29] SHOEMAKER, D. N., Notes on the development of *Hamamelis virginiana* L. Johns Hopkins Univ. Circ. **21**: 86–87. 1902.

[30] MASSART, I., Sur l'irritabilité des plants supérieures. I, II, III. Acad. Belgium Mém. Cour. et autres Mém. **62**: reprint, 60 pp. 1902.

many of his satisfied the reviewer[31] that no transmission occurs. Massart's method of experiment deserves imitation; his cultures were photographed at intervals on the same plate, without moving the camera. For the many individual results the paper must of course be read, but it may be noted here that stems and roots were found most irritable geotropically when horizontal. In the second paper it is shown that the secondary thickening of stems and nourishing roots of Ficus species climbing by clinging roots is localized on the less illuminated side. In Massart's terminology this is cataphotanisopachynosis, which tells the story "in a word." Several other instances of unequal thickening (anisopachynosis) are described and figured. The third paper treats of the aerial roots of Ficus. There are three kinds, and the geo-, photo-, and haptoneism (origin) and -tropism of each is described.— E. B. COPELAND.

PURE CULTURES of *Stichococcus bacillaris* have been again obtained by Matruchot and Molliard,[32] who have carried on some rather extensive experiments upon this alga when grown in various media. Although it does not need large amounts of oxygen for its development, it is not a true anaerobe. The glucoses appear to be the best food tested; dextrine, gum, glycerin, and mannite are all foods, but not as available as the glucoses; while the saccharoses (cane sugar, lactose, maltose) are hardly available at all. Salts of ammonium are foods, but nitrates are not assimilated. Several different concentrations of glucose and saccharose were tested. In stronger solutions the short diameter of the cells is diminished, the cells thus becoming somewhat longer in proportion to their width. It is to be regretted that the authors persist in the use of the percentage system in making up their solutions, and that they have made no observations on the influence of osmotic pressure *per se*. The plant develops normally in the dark. Some studies on the changes in the nucleus according to the culture medium were also made. Careful *quantitative* work in such researches as this would probably advance our knowledge of physiology much more rapidly than this sort of qualitative observation.— BURTON E. LIVINGSTON.

THE DEVELOPMENT of swarm-spores in Hydrodictyon is described in great detail in a recent paper by Timberlake.[33] The nucleus resembles that of the higher plants in the behavior of its chromatin, and also in having a well-defined nuclear membrane and a nucleolus. The spindle is bipolar, and at the poles there are sharply defined bodies which the writer interprets—and doubtless correctly—as centrosomes. When spores are about to be formed, a progressive cleavage takes place in the multinucleate protoplasm until the

[31] BOT. GAZ. **29**: 187–188. 1900.

[32] MATRUCHOT, L. et MOLLIARD M., Variations d'une algue verte sous l'influence du milieu nutritif. Rev. Gen. Bot. **40**: 114–130, 254–268, 316–332. 1902.

[33] TIMBERLAKE, H. G., Development and structure of the swarm-spores of Hydrodictyon. Trans. Wis. Acad. Sci. **13**: 486–522. *pls. 29–30*. 1902.

protoplasm becomes segmented into small portions, each containing a single nucleus. This segmentation is radically different from that which takes place in the endosperm of higher plants. It is entirely independent of nuclear divisions, and is accomplished by pairs of furrows pushing into the protoplasm from opposite directions, and not by intraplasmic vacuoles as described by Klebs. The spores have two cilia attached to a small, deeply staining granule just beneath the plasma membrane. It is too early even to suggest that this granule may be homologous with the blepharoplast of higher forms. Two delicate threads connect the granule with the nucleus. The cilia themselves stain like spindle fibers. After the spores come to rest, the pyrenoid, which disappears at the beginning of segmentation, again becomes visible. There is no organized chromatophore.—C. J. CHAMBERLAIN.

VALUABLE ADDITIONS to our knowledge of the process of respiration are outlined by Kostytschew[34] in a preliminary paper from the St. Petersburg laboratory. He has studied the effect of the nutrient medium upon intramolecular respiration in *Mucor stolonifer* and *Aspergillus niger*. The plants were grown in chambers closed from the air, through which a stream of pure nitrogen was passed during the entire experiment. The intensity of intramolecular respiration is measured in terms of the amount of CO_2 given off per gram of dry substance. Some of the results of the study are as follows: Intramolecular respiration occurs in pure water and in a variety of organic substances. In sugar, peptone, and acetates the intensity of the process is greater than in pure water, while in glycerin, free acetic acid, and quinic acid it equals or falls below that in water. In solutions of acetates *Mucor stolonifer* produces much oxalic acid, but in sugar solutions this substance is almost wholly lacking. Presence of zinc salts increases the amount of oxalic acid produced by Aspergillus. Low concentrations of the medium give greater respiratory intensity than higher ones, the optimum concentration being about two per cent. The author believes the last to be a purely osmotic effect, but the molecular weights of the substances used are so different that it is difficult to consider this proved until it is tested with solutions made up by modern methods.—BURTON E. LIVINGSTON.

DICOTYLEDONS with only one cotyledon still offer a problem to be solved. The latest paper on the subject deals with several of these so-called "pseudomonocotyledons."[35] The "pseudomonocotyledons" studied were *Eranthis hiemalis*, *Corydalis cava*, *Ranunculus Ficaria*, and *Bunium* (*Carum*) *Bulbocastanum*. *Corydalis nobilis* and *C. lutea*, forms which always have two cotyledons, were studied for comparison. *Cyclamen persicum* was also studied on account of its first leaf, which has sometimes been mistaken for a

[34] KOSTYTSCHEW, S. Der Einfluss des Substrates auf die anaerobe Athmung der Schimmelpilze. Ber. Deutsch. Bot. Gesell. **20**: 327–334. 1902.

[35] SCHMID, B., Beiträge zur Embryo-Entwickelung einiger Dicotyledonen. Bot. Zeit. **60**: 207–230. *pls. 8–10.* 1902.

cotyledon. In *Ranunculus Ficaria* there is hardly a trace of a second cotyledon. In *Corydalis cava* the prominent cotyledon gradually assumes a terminal position, causing a displacement of the stem tip so that it appears lateral. Occasionally there is a slight protuberance which might or might not be the rudiment of the other cotyledon. In Bunium also it was doubtful whether a slight protuberance might be interpreted as the rudiment of the missing cotyledon. In *Cyclamen persicum* embryos in the ripe seed show no trace of a second cotyledon. Attempts to induce the development of the missing cotyledon by removing the prominent one gave only negative results. The paper would doubtless have been more complete had it not been for the early death of the writer. The experimental part certainly deserves another trial. Bunium, which Schmid regarded as the form most favorable for experiment, was not investigated, because material in the proper stages was not available.—C. J. CHAMBERLAIN.

IN A RECENT SERIES of experiments upon the influence of diminished atmospheric pressure upon the photosynthetic process, Friedel[36] has discovered a curious condition of affairs. Young leaves of *Euonymus japonicus*, *Ruscus aculeatus*, and *Ligustrum japonicum*, and entire plants of *Lepidium sativum* were used. A diminution in atmospheric pressure produces first a decrease in the intensity of photosynthesis; then this intensity passes through a minimum, increases again to a maximum, and at last decreases to zero when a pressure of about one-tenth of an atmosphere has been reached. The minimum is from 0.4 to 0.6 of the normal intensity and is reached at a pressure between 0.4 and 0.5 of the normal atmospheric pressure. The maximum intensity (in Ruscus it is more than double the normal, in Ligustrum it is 0.7 of the normal) is reached at a pressure of 0.14 to 0.22 atmosphere. The author presents evidence that this is due to the joint action of two causes: (1) a decrease in the partial pressure of CO_2 brings about a fall in the intensity of photosynthesis, while (2) a decrease in the total atmospheric pressure occasions a rise. Changes in the partial pressure of oxygen alone have no effect. Also, an increase in the volume of the air in the experiment chamber causes a rise in photosynthetic activity. What may be the exact meaning of these facts it is impossible to conjecture. Perhaps these facts have some connection with the reputedly greater photosynthetic activity of alpine plants as compared with that of lowland forms.—BURTON E. LIVINGSTON.

MCKENNEY[37] has been conducting experiments upon the conditions of light production in luminous bacteria. His own summary of the chief results is as follows: (1) all acids are injurious to light production; a slight excess

[36] FRIEDEL, JEAN, L'assimilation chlorophyllienne aux pressions inférieures a la pression atmosphérique. Rev. Gen Bot. **40**: 337–355, 369–390. 1902.

[37] MCKENNEY, R. E. B., Observations on the conditions of light production in luminous bacteria. Proc. Biol. Soc. Washington **15**: 213–234. 1902.

of alkali is even more injurious than a slight excess of an acid; (2) the temperature limits for light emission are within those necessary for growth; (3) change of temperature, either sudden or gradual, is without effect on luminescence, i. e., does not stimulate; (4) there is no luminescence at or below 0°; (5) exposures to temperatures above the growth maximum are highly injurious to the power of light production, while exposure to very low temperatures seems to serve as a stimulus to light production; (6) *Bacillus phosphorescens* is capable of adapting itself to high temperatures, producing a race capable of light production at 35°, which is 5° above the normal maximum for luminescence; (7) a certain degree of continued illumination is without effect, and it is possible for the bacteria to live their entire lives in the dark and yet emit a brilliant light; (8) ether acts as a narcotic, preventing luminescence, but not growth and multiplication; (9) it is possible to develop a race of bacteria so immune to the action of small amounts of ether as to be still luminous in its presence; (10) peptone or related protein is required for the nutrition of luminous bacteria; (11) dextrose and certain of the higher sugars may be utilized advantageously by *B. phosphorescens;* (12) either sodium or magnesium is required for growth, and especially for light production; minimum, maximum, and optimum amounts of sodium are observed for growth and luminescence; (13) potassium, ammonium, lithium, rubidium, calcium, barium, and strontium cannot replace sodium (or magnesium).— J. M. C.

STRASBURGER[38] has recently published a very complete account of the morphology and biology of *Ceratophyllum submersum*, and has made this work the occasion for some interesting and important remarks upon phylogeny. As is well known, the pollen is discharged and pollination takes place under water. The anthers ripen in succession and an enormous quantity of pollen is produced, so that, in spite of the inevitable loss, most of the ovules produce seeds. The embryo sac shows nothing unusual in its structure. Double fertilization was observed and the chromosomes, twelve in the gametophyte and twenty-four in the sporophyte, were counted. The formation of the endosperm is peculiar. At the first division of the endosperm nucleus a transverse wall is formed, dividing the sac into two chambers, of which the one nearest the chalaza does not divide again; the other divides, and here again only the cell next the micropyle divides again. This method continues for a few divisions, and then walls are formed in three planes, giving rise to a small-celled tissue near the embryo, and a filament of a single row of cells at the chalazal end of the sac. In early stages the embryo is spherical, and there is no suspensor. At a later stage the embryo bears a striking resemblance to that of Nelumbo which Lyon described as having but one cotyledon and a lateral stem tip. Strasburger finds two cotyledons in Cera-

[38] STRASBURGER, E., Ein Beitrag zur Kenntniss von *Ceratophyllum submersum* und phylogenetische Erörterungen. Jahrb. Wiss. Bot. **37**: 477–526. *pls. 9–11.* 1902.

tophyllum, and after examining Nelumbo decides that here also there are two cotyledons, and that the apparently lateral origin of the stem tip is due to displacement. In Ceratophyllum not even the rudiment of a primary root is formed. The absence of a differentiated tissue in the cotyledon Lyon regards as a character not found in dicotyledons. The same structure appears in Ceratophyllum and Strasburger believes it is due to the fact that there is no primary root, the first functioning root coming from the stem above the cotyledon, practically the same condition as in Nelumbo; for, while Nelumbo has the rudiment of a primary root, it does not function, the first functional roots appearing as in Ceratophyllum. This, like the general reduction of the vascular system is regarded as an extreme adaptation to the water habit. Through such extreme adaptation the specific characters which indicate the place of the plant in the natural system are often obscured or even suppressed.

The latter part of the paper is devoted to a discussion of homology and phylogeny. Nothing but a careful reading of the entire paper could give an adequate idea of the views presented, but a few points may be mentioned. In establishing a natural system of organisms morphology will constantly be the guide, while to physiology will fall the task of clearing up the causes of influences, and of bringing definite forms and structures into relation to function. Natural selection has been overestimated; its function appears to be only that of removing the less valuable forms provided by mutation and direct influence. As Hertwig says, there are many cases in which the sequence of stages in ontogenetic development are caused by general laws of the development of living substance, but in many cases, like the water ferns, recapitulation is evident.— C. J. CHAMBERLAIN.

ITEMS OF TAXONOMIC INTEREST are as follows: M. L. FERNALD (Rhodora **4**: 213–216. 1902) has described a new variety (*obtusifolia*) of *Glaux maritima*.— PH. VAN TIEGHEM (Jour. Botanique **16**: 289–291. 1902) has described another new genus (*Periblepharis*) of Luxembourgiaceae.— L. M. UNDERWOOD (Torreya **2**: 172–173. 1902) has described 2 new species of Selaginella from North Carolina.—E. L. GREENE (Pittonia **5**: 57–106. 1902), in a fascicle of new Compositae, has described new species of Gaillardia (2), Laciniaria (2), Erigeron (2), and Chrysothamnus (12); has described 5 new species of Apocynum and 10 new species of Eriogonum; has revised the genus Euthamia to include 14 new species; has described 15 new species of Monardella, and 15 new species of Viola.—THEO. HOLM (Am. Jour. Sci. IV. **14**: 417–425. 1902) has described 3 new segregates of *Carex Tolmiei* Boott.— C. V. PIPER (Bull. Torr. Bot. Club **29**: 642–646. 1902), in his seventh paper on new and noteworthy northwestern plants, has described new species of Lupinus, Arctostaphylos, Phlox, Allocarya, Mertensia, Lonicera, and Aster (5).— In the publication of the Chinese *Plantae Bodinierianae*, MM. LÉVEILLÉ and EUG. VANIOT (Bull. Acad. Internat. Géog. Bot. **11**: 338–344. 1902) have

described 5 new species of Polygonum, and EUG. VANIOT (*idem* 345–351) has described 8 new species of Senecio.—In a fourth paper entitled "Descriptions of American Uredineae," J. C. ARTHUR and E. W. D. HOLWAY (Bull. Lab. Nat. Hist. Univ. Iowa **5**: 311–334. *pls. 1–9.* 1902) have presented the American rusts upon Agrostideae and Chlorideae, including 16 species, one of which is new. In only one species (*P. fraxinata*) is the full cycle of development traced.—C. S. SARGENT (Trees and shrubs, Part I. 1902) has published descriptions of 7 new species of Crataegus, a new Mexican genus (*Faxonanthus*, family not stated) by Greenman, a new Ehretia by Fernald, and 4 new species of Lonicera by Rehder.—A. ENGLER (Bot. Jahrb. **36**: 1–208. 1902), in his 24th contribution to the flora of Africa, has published an account of the plankton (Cyanophyceae and Chlorophyceae) of Nyassa and of other African lakes, by W. SCHMIDLE; a new genus (*Cycloschizon*) of Hysteriaceae by P. HENNINGS; 9 new species of Panicum by R. PILGER; 32 new species of Orchidaceae by F. KRÄNZLIN; a revision of Dichapetalaceae (24 n. spp.) by A. ENGLER and W. RUHLAND; a revision of Lentibulariaceae (51 species, including 10 n. spp. of Utricularia) by F. KAMIENSKI; a second paper on Moraceae (12 n. spp.), Urticaceae (14 n. spp.), Proteaceae (3 n. spp.), Violaceae (23 n. spp. of Rinorea), all by A. ENGLER; a third paper on Leguminosae (44 n. spp., the new genera being *Pseudoprosopis*, *Bussea*, *Dicraeopetalum*, *Pseudocadia*, and *Adenodolichos*) by H. HARMS; a second paper on Araliaceae (1 n. sp.) by H. HARMS; a sixth paper on Acanthaceae (21 n. spp.) by G. LINDAU; Dilleniaceae (7 n. spp.) by E. GILG; and the beginning of Capparidaceae by E. GILG.—A. ZAHLBRUCKNER (Beih. Bot. Centrabl. **13**: 11–163. 1902) has described 10 new Californian lichens collected by Dr. H. E. Hasse of Los Angeles, among them a new genus (*Hassea*).—I. URBAN (Symbolae Antillanae **3**: 280–352. 1902), in describing 56 new species of West Indian plants, has established new genera in Euphorbiaceae (*Chaenotheca*), Rhamnaceae (*Krugiodendron*), and Bombacaceae (*Neobuchia*).—F. STEPHANI (Bull. Herb. Boiss. II. **2**: 969–987. 1902) has described 16 new species of Plagiochila from Africa.—F. N. WILLIAMS (*idem* 1019–1021) has discovered that the puzzling Mexican *Abasoloa Taboarda* Llave & Lexarza is *Sabazia Michoacana* Robinson.—J. M. C.

RECENT TERATOLOGICAL LITERATURE.—DE CANDOLLE[39] presents a second contribution to our knowledge of the ascidia of Ficus, basing his observations on living material from the Botanical Gardens at Calcutta, where there are two young trees grown from cuttings from an older tree in the vicinity of Calcutta. The leaves of these trees he designates as hypoascidia, the inner surface of the ascidium representing the ventral surface of the leaf, as contrasted with epiascidia, the usual form in which the inner surface is homologous with the dorsal surface of the leaf.

[39] DE CANDOLLE, C., Nouvelle étude des Hypoascidies de Ficus. Bull. Herb. Boissier II. **2**: 753–762. *pls. 8–9.* 1902.

Stomata, corresponding in structure with those of *Ficus bengalensis*, with which they were compared, were abundant on the internal surface of the ascidium, but absent on the external surface, which contains the palisade tissue. Furthermore, the outer surface (the dorsal surface of the leaf) of the ascidium is provided with a hypodermis, which is interrupted here and there by a large cystolith-containing cell, neither of which is found on the inner surface. In addition to the normal form, two leaves were found in which two pouches were formed, one on either side of the midrib, by the coalescing of the inner surface of the ascidium with the midrib along a line opposite to the midrib. The course of the vascular system in both forms is described. Their ontogeny was also studied, the first indication of the formation of an ascidium being found in a leaf about 1.5^{mm} in length, while at a length of 4^{mm} the complete structure was found. The ascidium results from the formation of the lamina completely around the end of the petiole, and corresponds, except that it takes place in an inverse manner, with the development of ordinary epiascidia. As to whether the phenomenon is teratological in nature or whether the trees are to be regarded as representing a distinct species cannot yet be decided. The great age of the phenomenon would be indicated by the legends concerning the miraculous transformation of the leaves of an old banyan (*F. bengalensis*) from which these trees descended.

PENZIG[40] has also published teratological notes, most of which deal with foliar ascidia. In *Smilax aspera* he describes epiascidia in which the coalescence of the foliar margins occurs toward the apex instead of the base of the leaf. He designates this form as apical epiascidium, in contradistinction to the very common basal epiascidium. Apical epiascidia have hitherto been recorded in teratological literature in *Tulipa Gesneriana*. In *Carica Papaya* he figures and describes a large series of interesting malformations in accessory stalked laminae produced from the center of the leaves. This phenomenon in itself is so rare as to be of great interest, but this interest is greatly increased by the extraordinary conformation of the lamina of the accessory leaf. In the simplest form the leaf is a simple, basal epiascidium; in more frequent cases the modification represents twin ascidia (diplascidia), that is, one to the right and the other to the left of the midrib. Similar ascidia are frequent in *Saxifraga crassifolia*. The midrib may become free from the ventral surface or extend through the lower somewhat peltate portion of the lamina, bearing above a more or less completely developed ascidium. Several more or less perfectly formed ascidia, sometimes as many as four, may occur on the same midrib, in which case the forms alternate, a hypoascidium following an epiascidium and *vice versa*. The part of the paper dealing with ascidia is illustrated by forty well chosen and executed figures.

DISCHIDIA RAFFLESIANA has attracted the attention of several writers, as Wallich, Griffiths, Beccari, Treub, and Groom. Since 1890 it has been

[40] PENZIG, O., Note di Teratologia Vegetale. Malpighia **16**: 164–176. *pls. 4–6*. 1902.

grown with success at Kew. In 1893 Dr. Scott and Miss Sargant[41] published a study of the pitchers of this plant, basing their observations on the Kew material. Thistleton-Dyer adds a note[42] based on teratological material, "atavistic forms," as he designates them, which appeared after some ten years cultivation. The pitchers are morphologically leaves, the inner surface corresponding to the lower surface of the normal foliage leaf. The abnormal forms represent a series of transitions from a normal leaf to the pitcher by an increasing concavity of the under surface. The pitchers in the abnormal material differ, however, from the fully developed organ in the open mouth, uninflexed margins, and small size. Unless it be in one case, no indication was found of any such transition stage having been observed in nature. The production of pitchers is not a general characteristic of Dischidia, only a small part of the whole number of species having this habit. He considers that there can now be little doubt that the pitchers have as an ancestral form leaves such as those of *D. borneensis* Beec., and *D. collyris* Wall., in which the leaves are convex. He considers that the view of Treub, that the pitchers are water-economizers, corresponds most nearly with the facts, and while it is only in certain cases they collect rain water, under all circumstances they serve to preserve water lost by transpiration. The whole root system of the plant is adventitious and the pitchers are provided with a copious root system derived from one or more of a pair of aerial roots originating from the petiole or the closely adjacent stem. There can be little doubt, he thinks, that the roots utilize the humus contained in the pitchers as if it were ordinary soil, and accepts the suggestion of Groom that the organic matter is brought in by ants. He concludes, then, that there is in this plant a complex adaptation in which the leaves, originally developed for the purpose of storing and economizing water, often imperfectly perform this function and are then taken possession of by ants which supply solid in place of the liquid nutriment.

In Die Tropenpflanzen (**6**: 389. 1902) there is given a photograph of a "double" Ananas from the Azores. Harshberger[43] has recently written of the fasciation in the pineapple from Jamaica, where it seems to be not at all uncommon. Usually the form assumed is fan-shaped, the component fruits being arranged side by side, but sometimes one or more project, forming an irregularly disposed row. The smallest example examined consisted of two united fruits, while the largest, twenty inches across and twelve inches high, was composed of a dozen or more.

[41] Annals of Botany **7**: 243–269. *pls. 11–12.* 1893.

[42] Thistleton-Dyer, W. T., Morphological notes. VII. Evolution of pitchers in *Dischidia rafflesiana*, Annals of Botany **16**: 365–369. *pls. 14–15.* 1902.

[43] Harshberger, J. W., Coxcomb fasciation of pineapples. Proc. Acad. Sci. Philad. **53**: 609–611. 1902.

FASCIATION in the sweet potato is the subject of a paper by Conard,[44] who gives observations on the frequency of occurrence and the form and histology of the formation in its usual type as well as in the interesting condition known as "ring-fasciation." Besides the description of his own material, he refers quite extensively to other forms and to the literature—a virtue in which so many of the teratological papers are sadly deficient.

CARLETON E. PRESTON (Amer. Nat. **36**: 727–734. *figs. 10.* 1902) considers the foliage of Acacia and finds considerable variation in the forms of the pinnate leaves. In the production of the phyllodia he found some forms which, while they may be mere anomalies, might seem to indicate that this organ may not be entirely petiolar in nature, the rachis as well as the petiole being concerned in its formation, and the pinnae dropping from the base or the tip of the central axis.—PENZIG (*loc. cit.*) describes and figures among others an abnormality in the flower of *Gladiolus segetum.* The abnormal example shows a perianth of nine instead of six parts, four instead of three stamens, and a five-parted stigma with an ovary of five carpels instead of the usual number.—COPELAND (BOT. GAZ. **34**: 142–144. *figs. 5.* 1902) describes and figures abnormal forms of *Asplenium pinnatifidum* Nutt. and *Polypodium vulgare* L. found on the Laurel ridge in northern West Virginia, and suggests that, while they are not necessarily any support for the theory of De Vries as to the origin of new species, the value of the study of such freaks as these in connection with the questions De Vries has raised is self-assertive.—EICHLER (Jahreshefte der Ver. vaterl. Naturk. in Württemberg **58**: LXXI–LXXII. 1902) gives some brief notes of a teratological nature and also some suggestions on xenia and double fertilization.—PERROT (Bull. Soc. Bot. France **49**: 163–166. *figs. 6.* 1902) publishes observations on the general form and histological structure of excrescences found on the ventral surface of leaves of *Aristolochia Sipho,* and suggests that the excrescences are the result of an effort to increase the transpiration surface. The formations clearly belong to those occurring in various species of plants which have been designated as "seam-like" outgrowths. No reference is made to the literature. The formation has been described for this species by a half-dozen or more writers.—CAMUS figures and very briefly describes (Bull. Soc. Bot. France **49**: 70–71. *pl. 1.* 1902) monstrosities in *Salix hippophaefolia* Thuill. caused by *Ceidomya rosaria* H. Lev.—PROLIFICATION in the pear, where it has frequently been described, is noted and figured in the *Lyon Horticole* (**24**: 81–85. 1902), and prolification of the fruit of Capsicum, a very common occurrence and one which has been three or four times treated in the literature, is figured in a later number of the same journal (**24**: 382–385. 1902).—J. ARTHUR HARRIS.

[44] CONARD, H. S., Fasciation in the sweet potato. Contrib. Bot. Lab. Univ. Penn. **2**: 205–215. *pl. 19.* 1902.

JUEL,[45] while traveling in Tunis, secured a specimen of the curious parasite *Cynomorium coccineum*, and succeeded in keeping it alive until he had secured material for the entire life-history except the seed and seedlings, and even this gap was filled later from material collected in Trapani. He had thought that a careful study might reveal some such condition as that described by Treub for Balanophora, but fertilization and the formation of the embryo take place in the usual manner, as had already been shown by Pirotta and Longo. The behavior of the megaspore mother-cell is peculiar. The two cells resulting from the first division of the megaspore mother-cell are very unequal, the one nearest the micropyle being considerably smaller. This smaller cell divides longitudinally and the larger one transversely, thus giving rise to four megaspores, of which the one nearest the chalaza develops at the expense of the other three. The peculiar arrangement of the four megaspores and their inequality in size are habitual, having been noted in twenty cases. Artificial pollination showed that fertilization takes place four days after pollination; sixteen days after pollination embryos of various sizes were found. The antipodals do not divide, as described by Pirotta and Longo, but may be distinguished as three undivided cells even after the endosperm has become abundant. In the ripe seed the embryo is a small spherical mass of cells with no suspensor and no differentiation into body regions.—CHARLES J. CHAMBERLAIN.

[45] JUEL, H. O., Zur Entwickelungsgeschichte des Semens von Cynomorium. Beih. Bot. Centralbl. **13**: 194–202. *figs.* 5. 1902.

NEWS.

ED. REINECK has succeeded the late G. Leimbach as editor of the *Deutsche botanische Monatsschrift.*

Dr. P. P. DEHÉRAIN, professor of plant physiology at the Muséum d'Histoire Naturelle at Paris, and editor of the *Annales Agronomiques*, died recently.

ON NOVEMBER 27 a celebration was held in honor of M. Chr. Gobi, professor emeritus of the Imperial University of St. Petersburg, to commemorate the completion of thirty years of activity in teaching and investigation.

THE OFFICERS of the Botanical Society of Washington for 1903 are A. F. WOODS, president; FREDERICK V. COVILLE, vice-president; CHARLES L. POLLARD, recording secretary; HERBERT J. WEBBER, corresponding secretary; and WALTER H. EVANS, treasurer.

PROFESSOR L. CELAKOVSKY, professor of botany and director of the botanical institute and gardens of the University of Prag, died November 24 last, at the age of sixty-seven years. His numerous botanical contributions are well known, and his death has removed one of the most constant contributors to botanical literature.

E. P. BURTON & Co., a lumber firm of Charleston, S. C., have asked for the help of the Bureau of Forestry in managing 60,000 acres of pine forest about thirty miles northwest of Charleston, on the Cooper River. The forest consists mainly of loblolly, with some longleaf and spruce pine. It contains also some large swamps with heavy stands of cypress, gum, and oaks.

THE UNIVERSITY OF MICHIGAN has secured the lease of a piece of ground containing about seven acres for a botanical garden and arboretum. The land is located in immediate proximity to the campus and adjacent to other university property. It includes a "kettle hole," which will be utilized for the growth of aquatics, and has the advantage of great variety of slope, soil, and exposure. The front nearest to the university buildings is reserved for the erection of a conservatory with workrooms.

DR. A. WAGNER, of the University of Innsbruck, has announced the publication of a new periodical to be entitled "Botanisches Litteraturblatt." It is to be an "organ for author reports of the whole domain of botany." The "autoreports" of foreign authors, if not written in German, will be published in "literal German translation." The publisher is Wagner, bookseller to the University of Innsbruck. In case an author declines to furnish a report of

his paper, "eventual reports will be reserved to the editor." The subscription "for the first annual course" (twenty-four numbers) is *Kro.* 28.

THE FIRST NUMBER of *The Forestry Quarterly* has made its appearance, bearing the date October, 1902. It is published under the direction of the New York State College of Forestry at Ithaca, and has for its objects to aid in the establishment of rational forest management, to be an organ for the publication of technical papers on forestry, and to keep those interested in forestry in touch with the current technical literature and the forestry movement in the United States. The *Forestry Quarterly* is the only publication in this country devoted entirely to the interests of the seience of forestry. A valuable feature is its review of current literature. The annual subscription price is one dollar.

THE BUREAU OF FORESTRY has shown the damage caused by forest fires in northwestern Oregon and southeastern Washington during September, and a conservative estimate places the damage at $12,767,100. Of this amount $8,857,100 is in Washington. The estimate includes losses to farm property, saw mills, manufactured lumber, standing timber, etc., and is based on personal observation, conferences with lumber men, farmers, settlers, and other trustworthy sources of information. Much of the area burned over was covered with virgin forest, mainly of Douglas spruce, cedar, and hemlock. Since most of the fires could have been extinguished before they became serious, it is evident that an efficient system of forest patrol would have prevented most of this loss.

THE OFFICE of experiment stations, U. S. Department of Agriculture, has published (Exp. Sta. Record **14**: No. 3) an account, prepared by DR. WALTER H. EVANS, of the International Conference on plant-breeding and hybridization held in New York city September 30 to October 2, 1902, under the auspices of the Horticultural Society of New York. A program of over fifty papers was presented, and all of them are to be published in full in Proc. N. Y. Hort. Soc. The account referred to above gives synopses of certain papers, among which are the following: Practical aspects of the new discoveries in heredity, W. BATESON; Notes on Mendel's methods of plant-breeding, C. C. HURST; Artificial ataviem, HUGO DE VRIES; Some suggestions for plant-breeding, MAX LEICHTLIN; Some suggestions for the classification of hybrids, I. T. LYNCH; Principles of plant-breeding, LUTHER BURBANK; Breeding of disease-resistant varieties, W. A. ORTON; Breeding for intrinsic qualities, W. M. HAYS; Correlation between different parts of the plant in form, color, and other characteristics, S. A. BEACH; The varying tendency and individual prepotency in garden vegetables, W. W. TRACY; Cross-fertilization of the sugar cane, D. MORRIS; Cytological aspects of hybrids, W. A. CANNON; A medley of pumpkins, L. H. BAILEY.

DR. TIMOTHY FIELD ALLEN died at his home in New York city December 5, 1902. He was born in Westminster, Vt., April 24, 1837, and was

therefore in his sixty-sixth year. Dr. Allen was one of the organizers of the Torrey Botanical Club, and until the last two or three years, when failing health compelled a partial retirement, was one of the leading spirits in its work. He was early interested in the local flora of the New York city region and assisted in the publication of local lists of the higher plants. His attention, however, was soon drawn to the Charales, and he was for many years the best known American student of this taxonomically difficult group of plants. His extensive collections of Charales, especially rich in North American and Japanese forms, together with his books relating to this order of plants, including the duplicate stock of his own publications, were given to the New York Botanical Garden early in 1901. Dr. Allen was for a long time professor of materia medica and dean of the New York Homoeopathic Medical College, and later president of its board of trustees. He was also president of the New York Ophthalmic Hospital. He was the author of a large work on materia medica and of numerous papers on ophthalmology, etc. In 1885 the degree of LL.D. was conferred upon him by Amherst College, from which he was graduated in 1858.